academicJournals

Vol. 8(3), pp. 60-89, March 2016
DOI: 10.5897/JPP2015.0372
Article Number: 6CD2BEB57371
ISSN 2141-2502

http://www.academicjournals.org/JPP

Journal of Pharmacognosy and Phytotherapy

Full Length Research Paper

Study of chemical composition of *Foeniculum vulgare* using Fourier transform infrared spectrophotometer and gas chromatography - mass spectrometry

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Receive August 29 2015; Accepted 29 October, 2015

Medicinal plants are potential sources of natural compounds with biological activities and therefore attract the attention of researchers worldwide. The objective of this research was to determine the chemical composition of seeds extract from methanol. The phytochemical compound screened by gas chromatography - mass spectrometry (GC-MS) method. Fifty six bioactive phytochemical compounds were identified in the methanolic extract of *Foeniculum vulgare*. The identification of phytochemical compounds is based on the peak area, retention time molecular weight, molecular formula, MS Fragment- ions and Pharmacological actions. The Fourier transform infrared spectroscopy (FTIR) analysis of F. vulgare seeds proved the presence of alkenes, aliphatic fluoro compounds, alcohols, ethers, carboxlic acids, esters, nitro compounds, alkanes, hydrogen bonded alcohols and phenols.

Key words: Gas chromatography - mass spectrometry (GC-MS), bioactive compounds, Fourier transforminfrared spectroscopy (FT-IR), Foeniculum vulgare.

INTRODUCTION

Bitter Fennel (*Foeniculum vulgare* Mill.) is one of the oldest herbs and possesses beneficial medicinal effects, belongs to the Apiaceae family and native to Mediterranean regions (Hornok, 1992). In botany the Umbllifererae (apiaceae) family is widespread and includes 300 genus and 3000 aromatic herbaceous species (Hay et al., 1993). *F. vulgare* is a well known aromatic medicinal plant which is used in traditional medicine as spice and substrate for different industrial purpose (Telci et al., 2009). Fennel is used for various purposes in the food, cosmetic, and medical industries. Fennel essential oil has a valuable antioxidant, and has antibacterial, anticancer and antifungal activity (Lucinewton et al., 2005; El-Awadi and Esmat, 2010; Altameme et al., 2015a). It is cultivated and also widespread in many parts of Mediterranean and midlist countries such as Italy, Turkey and Iran (Marino et al., 2007; Altameme et al., 2015b). The increasing commercial value of fennel necessitates the need to identification, recognizing and conservation the existing diversity. The fruits of sweet fennel contain essential oil which is rich source of anethole, limonene, fenchone,

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estragole and camphene among them the anethole is the most important constituent with determinant role in quality of the essential oil of seeds (Gross et al., 2002; Hameed et al., 2015a). These depend upon internal and external factors affecting the plant such as genetic structures and ecological conditions (Telci et al., 2009).

MATERIALS AND METHODS

Collection and preparation of plant material

The seeds were dried at room temperature for seven days and when properly dried then powdered using clean pestle and mortar, and the powdered plant was size reduced with a sieve. The fine powder was then packed in airtight container to avoid the effect of humidity and then stored at room temperature (Hameed et al., 2015b).

Preparation of sample

About four grams of the plant sample powdered were soaked in 50 ml methanol individually. It was left for two weeks so that alkaloids, flavonoids and other constituents if present will get dissolved (Hameed et al., 2015c). The methanol extract was filtered using Whatman No.1 filter paper and the residue was removed (Hamza et al., 2015).

Identification of component by gas chromatography - mass spectrum analysis

The physicochemical properties of *F. vulgare* are presented in Table 1. Interpretation of mass spectroscopy (GC-MS) was conducted using data base of National Institute Standard and Technology (NIST) having more than 62000 patterns. The spectrum of the unknown component was compared with the spectrum of the known component stored in the NIST library (Mohammed and Imad, 2013; Imad et al., 2014a). The identity of the components in the extracts was assigned by the comparison of their retention indices and mass spectra fragmentation patterns with those stored on the computer library and also with published literatures. The GC-MS analysis of the plant extract was made in a Agilent 7890 A instrument under computer control at 70 eV. About 1 µL of the methanol extract was injected into the GC-MS using a micro syringe and the scanning was done for 45 min. As the compounds were separated, they eluted from the column and entered a detector which was capable of creating an electronic signal whenever a compound was detected. The greater the concentration in the sample, bigger was the signal obtained which was then processed by a computer (Imad et al., 2014b; Hameed et al., 2015d). The time from when the injection was made (Initial time) to when elution occurred is referred to as the Retention time (RT). While the instrument was run, the computer generated a graph from the signal called Chromatogram. Each of the peaks in the chromatogram represented the signal created when a compound eluted from the gas chromatography column into the detector. The X-axis showed the RT and the Y-axis measured the intensity of the signal to quantify the component in the sample injected. As individual compounds eluted from the Gas chromatographic column, they entered the electron ionization (mass spectroscopy) detector, where they were bombarded with a stream of electrons causing them to break apart into fragments. The fragments obtained were actually charged ions with a certain mass. The M/Z (Mass / Charge) ratio obtained was calibrated from the graph obtained, which was called as the mass spectrum graph which is the fingerprint of a molecule. Before analyzing the extract using gas chromatography and mass spectroscopy, the temperature of the oven, the flow rate of the gas used and the electron gun were programmed initially. The temperature of the oven was maintained at 100°C. Helium gas was used as a carrier as well as an eluent. The flow rate of helium was set to 1 ml per minute (Imad et al., 2014c; Kareem et al., 2015). The column employed here for the separation of components was Elite 1(100% dimethyl poly siloxane).

Fourier transform infrared spectrophotometer (FTIR)

The powdered sample of *Euphorbia lathyrus* specimen was treated for FTIR spectroscopy (Shimadzu, IR Affinity 1, Japan). The sample was run at infrared region between 400 and 4000 nm (Hussein et al., 2015; Jasim et al., 2015).

RESULTS AND DISCUSSION

Gas chromatography and mass spectroscopy analysis of compounds was carried out in methanolic seed extract of *F. vulgare*, shown in Table 1. The GC-MS chromatogram of the 56 peaks of the compounds detected was shown in Figure 1. Chromatogram GC-MS analysis of the methanol extract of *F. vulgare* showed the presence of fifty six major peaks and the components corresponding to the peaks were determined as follows. The first set up peak were determined to be Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl. The second peak indicated to be L-Fenchone. The next peaks considered to be α-D-Glucopyranoside,O-α-D-glucopyranosyl-(1.fwdarw.3)-ß-D-fructo, 2-Propyl-tetrahydropyran-3-ol, Estragole, 6-Methylenebicyclo[3.2.0]hept-3-en-2-one, Benzaldehyde ,4-methoxy, Anethole, 2,5-Octadecadiynoic acid , methylester, 2-Methoxy-4-vinylphenol, Ascaridole epoxide, d-Mannose, Benzenemethanol, 2-(2-aminopropoxy)-3-methyl-, 2-Propanone, 1-(4-methoxyphenyl), Pterin -6-carboxylic acid, Cyclopenta [1,3]cyclopropa[1,2]cyclohepten-3(3aH)-one,1,2,3b,6,7, 4-Methoxybenzoic acid, allyl ester, Arisaldehyde dimethyl acetal, Propiolic acid, 3-(1-hydroxy-2-isopropyl-5-methylcyclohexyl), Benzenemethanol,2-(2-aminopropoxy)-3-methyl, 1-Heptatriacotanol, 1-propyl-3,6-diazahomoadamantan-9-ol, Benzhydrazide , 4-methoxy-N2-(2-trifluoroacetylcyclohepten-1-yl), 4-(2,5-Dihydro-3-methoxyphenyl) butylamine, 2-Hydroxy-2-(4-methoxy-phenyl)-N-methyl – acetamide, Corymbolone, Apiol, Spiro[4.5]decan-7-one,1,8-dimethyl-8,9-epoxy-4-isopropyl, Fenretinide, Dihydroxanthin, 9-Ethoxy-10-oxatricyclo[7.2.1.0(1,6)]dodecan-11-one, Bicyclo[4.3 .0]nonan-7-one,1-(2-methoxyvinyl), 1-(4-methoxyphenyl)-1,5-pentanediol, Aceta-mide,N-methyl-N-[4-(3-hydroxypyrrolidinyl)-2-butynyl], Gibberellic acid, 2,3-Dimethoxy-5-methyl-6- decaisoprenyl- chinon, Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cym, [1,2,4]Triazolo[1,5-a]pyrimidin-7(4H)-one,5-methyl-6-(3-methylbutyl)-, 2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5 -trienyl]cyclo, Cis-Vaccenic acid, 6,9,12,15-

Table 1. Major phytochemical compounds identified in methanolic extract of *Foeniculum vulgare.*

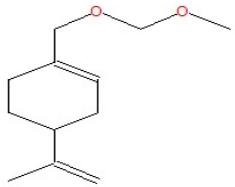
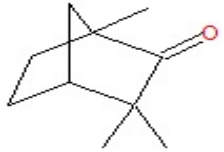
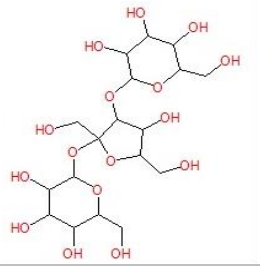
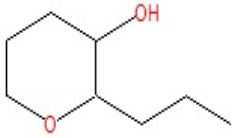
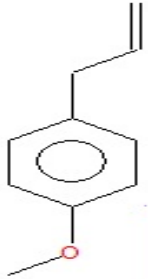
Serial No.	Phytochemical compound	RT (min)	Molecular weight	Exact mass	Chemical structure	MS fragmentations	Pharmacological actions
1	Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl-	4.117	196	196.14633		53, 79, 91, 119, 164, 196	Anti periodic *effect*
2	L-Fenchone	4.935	152	152.120115		53, 69, 81, 91, 109, 123, 137, 152	Anti-tumour activity
3	α-D-Glucopyranoside,O-α-D-glucopyranosyl-(1.fwdarw.3)-ß-D-fructo	5330	504	504.169035		60, 69, 73, 81, 85, 97, 113, 126133, 145, 163, 175, 187, 199	Unknown
4	2-Propyl-tetrahydropyran-3-ol	5.936	144	144.115029		55, 73, 87, 101, 116, 144	Anti-angiogenic effect
5	Estragole	6.331	148	148.088815		51, 55, 63, 77, 91, 105, 121, 133, 148	Anti-inflammatory activity

Table 1. Cont'd

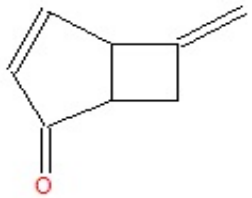
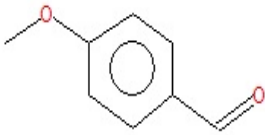
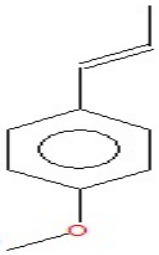
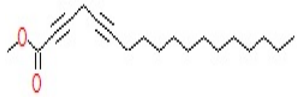
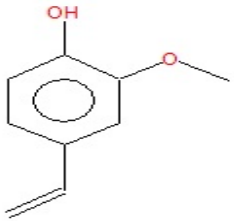
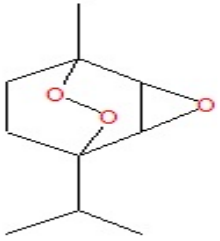
6	6-Methylenebicyclo[3.2.0]hept-3-en-2-one	6.806	120	120.0575147		51, 65, 77, 91, 120	Biological activities, including bacteriostatic, fungistatic, anti-parasitic
7	Benzaldehyde ,4-methoxy-	7.201	136	136.052429		50, 63, 77, 92, 107, 119, 135	Anti-Toxoplasma gondii activity
8	Anethole	7.619	148	148.088815		51, 55, 63, 74, 7791, 105, 117, 121, 1333, 148	Anti-edematogenic effects
9	2,5-Octadecadiynoic acid , methylester	7.802	290	290.22458		55, 67, 79, 91, 105, 117, 131, 145, 159	Anti-inflammatory
10	2-Methoxy-4-vinylphenol	7.933	150	150.06808		51, 63, 77, 89, 107, 118, 135	Antioxidant, anti microbial and anti inflammatory
11	Ascaridole epoxide	8.437	184	184.109944		55, 69, 79, 91, 97, 107, 135, 150, 168	Anti-carcinogenic effects

Table 1. Cont'd

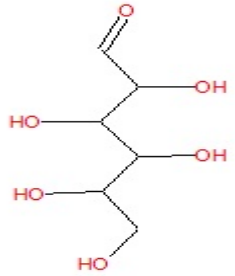
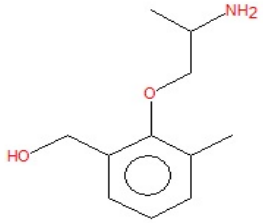
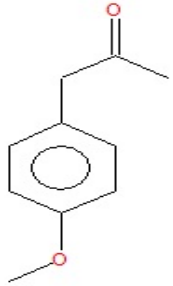
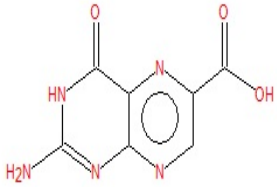
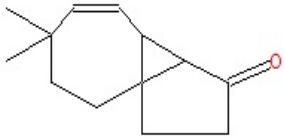
12	d-Mannose	8.225	180	180.063388		60, 73, 85, 103, 131, 149, 179	Anti-arrhythmic effect
13	Benzenemethanol , 2-(2-aminopropoxy)-3-methyl-	8.540	195	195.125929		58, 91, 121, 152, 178	Anti-microbial, anti-cancer and anti-malarial
14.	2-Propanone, 1-(4-methoxyphenyl)-	8.912	164	164.08373		51, 65, 78, 91, 106, 121, 135, 164	Antiviral, anti-inflammatory, antimalarial and antibacterial
15	Pterin -6-carboxylic acid	9.038	207	207.039239		57, 69, 105, 149, 163, 177, 207	Unknown
16	Cyclopenta [1,3]cyclopropa[1,2]cyclohepten-3(3aH)-one,1,2,3b,6,7	9.330	190	190.135765		69, 78, 91, 119, 133, 147, 162, 190	Anti-pain effect

Table 1. Cont'd

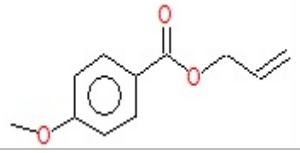
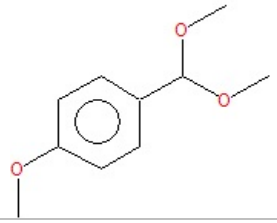
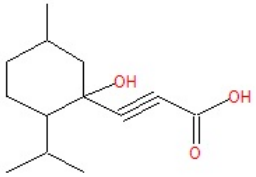
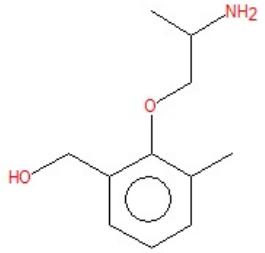
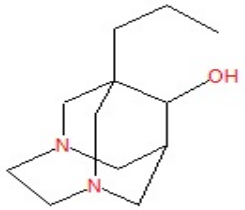
17	4-Methoxybenzoic acid , allyl ester	9.673	192	192.078644		50, 64, 77, 85, 92, 107, 120, 135, 147, 152, 177	Anti-inflammatory, antiviral, antibacterial
18	Arisaldehyde dimethyl acetal	9.965	182	182.094295		51, 65, 77, 92, 108, 121, 135, 151, 165, 182	Neurotoxicity and anti-inflammatory effects
19	Propiolic acid , 3-(1-hydroxy-2-isopropyl-5-methylcyclohexyl)	10.354	224	224.141245		55, 81, 95, 109, 135, 163, 178, 191, 206	Anti-cancer
20	Benzenemethanol,2-(2-aminopropoxy)-3-methyl-	10.434	195	195.125929		58, 65, 77, 91, 105, 121, 152, 178, 195	Anti-nociceptive effect
21	1-Heptatriacotanol	10.777	536	536.58962		55, 81, 95, 147, 161, 190, 229, 244, 257	Anti-Mycobacterium tuberculosis Activity
22	1-propyl-3,6-diazahomoadamantan-9-ol	10.857	210	210.173213		58, 72, 82136, 181, 210	Unknown

Table 1. Cont'd

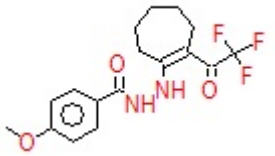
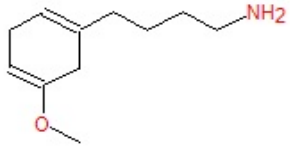
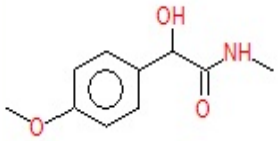
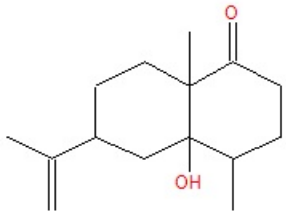
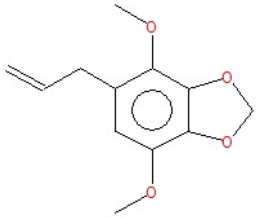
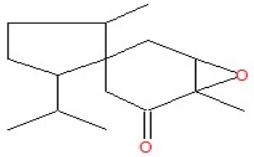
23	Benzhydrazide , 4-methoxy-N2-(2-trifluoroacetylcyclohepten-1-yl)	10.960	356	356.134777		64, 77, 92, 107, 115, 135, 153, 175, 203	Antimalarial, anti-inflammatory
24	4-(2,5-Dihydro-3-methoxyphenyl)butylamine	11.172	181	181.146665		55, 65, 77, 91, 107, 121, 134, 150	Antitumor, antispasmolytic, estrogenic, antiviral and anti-helminthic
25	2-Hydroxy-2-(4-methoxy-phenyl)-N-methyl – acetamide	11.384	195	195.089543		66, 77, 94, 109, 137, 148, 178, 195	Anti-inflammatory and antibacterial
26	Corymbolone	11.618	236	236.17763		55, 69, 93, 109, 135, 175, 203, 218	Anti-fungal agent
27	Apiol	11.727	222	222.089209		53, 65, 77, 91, 106, 121, 149, 161, 177, 191, 207, 222	Phytotoxic activity and antifungal activity
28	Spiro[4.5]decan-7-one,1,8-dimethyl-8,9-epoxy-4-isopropyl	11.910	236	236.17763		55, 69, 81, 95, 109, 123, 137, 151, 165, 193, 208, 236	Anti-inflammatory activity

Table 1. Cont'd

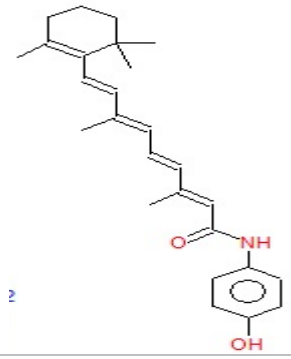
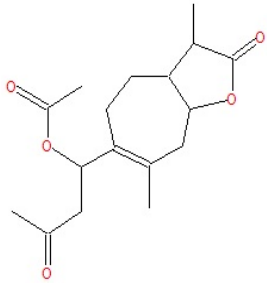
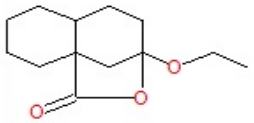
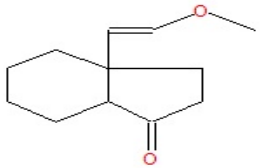
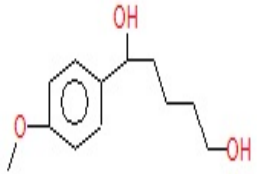
29	Fenretinide	12.013	391	391.25113		58, 69, 81, 95, 109, 119, 135, 148, 161, 202, 213, 255, 268	Anti-tumoural activity
30	Dihydroxanthin	12.196	308	308.162374		55, 79, 95, 137, 151, 178, 206, 248	Unknown
31	9-Ethoxy-10-oxatricyclo[7.2.1.0(1,6)]dodecan-11-one	12.357	224	224.141245		55, 67, 79, 93, 109, 124, 137, 151, 168, 180, 196, 225	Anticancer effect
32	Bicyclo[4.3.0]nonan-7-one,1-(2-methoxyvinyl)-	12.591	194	194.13068		67, 79, 91, 138, 151, 163, 179, 194	Unknown
33	1-(4-methoxyphenyl)-1,5-pentanediol	12.723	210	210.125594		59, 71, 77, 94, 109, 121, 137, 147, 192, 210	Antipyretic, anti-inflammatory, hematological effects, antimicrobial, antiviral and antitumor

Table 1. Cont'd

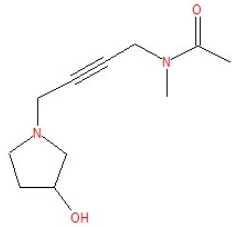
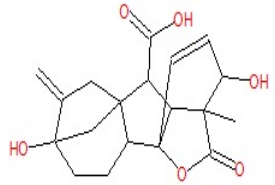
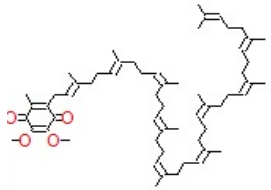
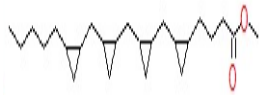
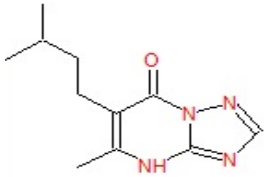
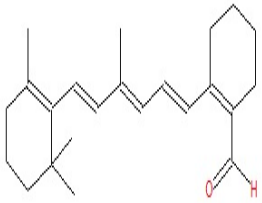
34	Acetamide,N-methyl-N-[4-(3-hydroxypyrrolidinyl)-2-butynyl]	13.804	308	308.162374		56, 68, 124, 192	Unknown
35	Gibberellic acid	14.353	346	346.141638		55, 77, 91, 121, 136, 152, 203, 239, 300, 328	Significant anti-ageing, anti-carcinogenic, and anti-thrombotic effects
36.	2,3-Dimethoxy-5-methyl-6-decaisoprenyl- chinon	14.514	862	862.68391		55, 69, 81, 95, 135, 149, 197, 235, 250, 313, 340, 384	New chemical compound
37	Cyclopropanebutanoic acid , 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cy	14.806	374	374.318481		55, 67, 74, 95, 121, 135, 149, 161, 199, 227, 270, 298, 334	Anti-inflammatory, antioxidant, antimalarial, anti-tuberculosis and antifungal
38	[1,2,4]Triazolo[1,5-a]pyrimidin-7(4H)-one,5-methyl-6-(3-methylbutyl)-	15.120	220	220.132411		53, 67, 80, 95, 109, 122, 136, 164, 177, 220	Unknown
39	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclo	16.916	324	324.245316		55, 69, 79, 91, 105, 135, 173, 187, 255, 324	Antimicrobials and *anti*-virals

Table 1. Cont'd

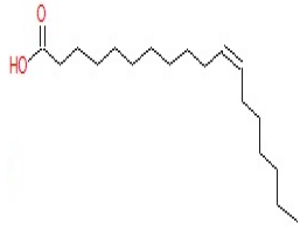
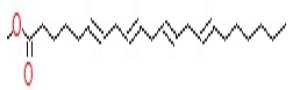
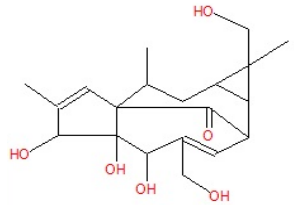
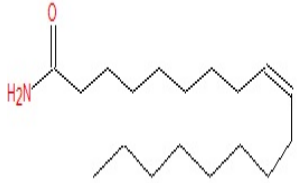
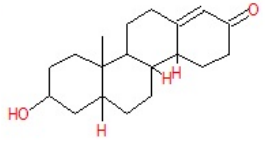
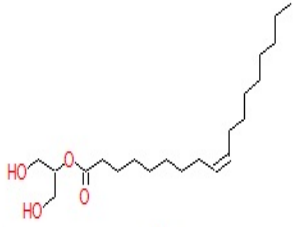
40	Cis-Vaccenic acid	17.621	282	282.25588		55, 69, 83, 97, 111, 125, 165, 193, 222, 246, 264, 282	Anti-carcinogenic effect
41	6,9,12,15-Docosatetraenoic acid , methyl ester	18.382	346	346.28718		55, 67, 93, 107, 121, 149, 164, 177, 209, 235, 264, 346	Anti-carcinogenic and anti-atherosclerotic effects
42.	1H-2,8a-Methanocyclopenta[a]cyclopropa[e]cyclodecen-11-one,1-	18.645	364	364.18859		53, 65, 77, 121, 151, 269, 333, 364	Anti-tumor activity
43	9-Octadecenamide,(Z)-	19.040	281	281.271864		59, 72, 83, 114, 184, 212, 264, 281	Anti-inflammatory activity and antibacterial activity
44	dl-3Beta-hydroxy-d-homo-18-nor-5alpha,8alpha,14beta-androst-13(1)	20.144	288	288.208931		55, 79, 110, 147, 165, 216, 255, 270, 288	Anti-inflammatory
45	9-Octadecenoic acid (Z)-,2-hydroxy-1-(hydroxymethyl)ethyl ester	21.512	356	356.29266		55, 69, 81, 98, 137, 151, 165, 221, 264, 280, 325, 354	Antimicrobial, Anticancer, Diuretic and Anti-inflammatory

Table 1. Cont'd

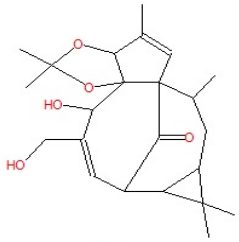
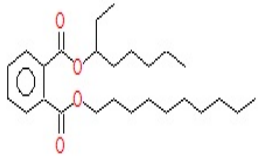
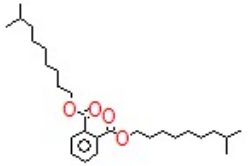
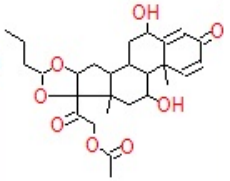
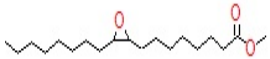
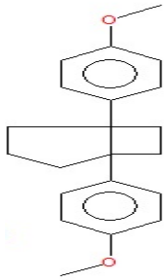
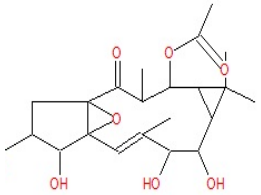
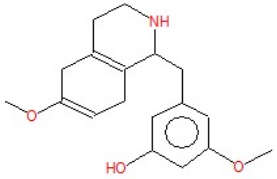
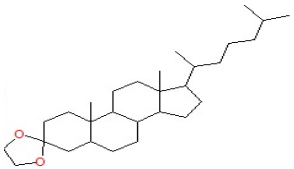
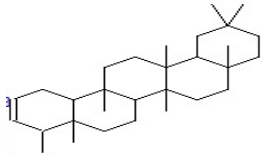
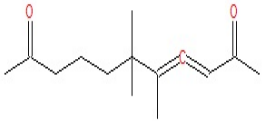
46	5aH-3a,12-methano-1H-cyclopropa[5´,6´]cyclodeca[1´,2´:1,5]cyclo	22.433	388	388.224974		55, 77, 91, 122, 149, 177, 213, 299, 330	Anti-inflammatory effect
47	Phthalic acid , decyl oct-3-ylester, 1,2-Benzenedicarboxylic acid , bis(8-methylnonyl)ester,	23.434	418	418.30831		57, 104, 149, 167, 193, 251, 307	New chemical compound
48	1,2-Benzenedicarboxylic acid , bis(8-methylnonyl)ester	24.355	446	446.33961		71, 99, 149, 167, 193, 228, 289, 307, 321, 361, 389, 417	Anti-leishmanial activity
49	(22S)-21-Acetoxy-6α,11ß-dihydroxy-16α,17α-propylmethylenedioxyp	25.357	488	488.241018		55, 79, 91, 121, 149, 223, 279, 297, 351, 387, 416, 445, 488	Anti-inflammatory
50	Oxiraneoctanoic acid , 3-octyl-,methyl ester	25.591	312	312.266445		55, 74, 97, 155, 199, 214, 263, 281, 312	Antibacterial activity
51	1,5-Bis(4-methoxyphenyl)bicyclo[3.2.0]heptane	25.723	308	308.17763		57, 71, 91, 148, 174, 249, 280, 308	Anti-HIV agent

Table 1. Cont'd

52	Ingol 12-acetate	26.169	408	408.214804		55, 122, 137, 165, 192, 245, 273, 301, 330, 377, 408	Anti-inflammatory *activity*
53	Isoquinoline,1-[3-methoxy-5-hydroxybenzyl]-1,2,3,4,5,8-hexahydro-	26.301	301	301.167793		55, 77, 121, 164, 210, 268, 299	Anti-cancer activities
54	Cholestan-3-one , cyclic 1,2-ethanediyl aetal,(5ß)-	26.541	430	430.38108		55, 69, 99, 125, 149, 194, 232, 282, 340, 384, 430	Anti-inflammatory agents
55	2,24a,6a,8a,9,12b,14a-Octamethyl-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,1	27.279	410	410.391253		55, 69, 81, 95, 109, 136, 191, 205, 218, 257, 287, 342, 367, 395, 410	Anti-diarrhoeal activity
56	Undeca -3,4-diene-2,10-dione,5,6,6-trimethyl-	28.464	222	222.16198		55, 69, 123, 137, 179, 222	New chemical compound

hydrogen bonded alcohols and phenol which shows major peaks at 719.54, 889.18, 1029.99, 1141.86, 1244.09, 1317.38, 1373.32, 1595.13, 2677.20, 2852.72, 2922.16, 3005.10, 3244.27 and 3361.993 (Table 2 and Figure 60).

Conclusion

F. vulgare is native plant of Iraq. It contain chemical constitutions which may be useful for various herbal formulation as anti-inflammatory, analgesic, antipyretic, cardiac tonic and antiasthamatic.

Conflict of Interests

The authors have not declared any conflict of interest.

ACKNOWLEDGMENTS

The authors wish to express their deepest gratitude to Prof. Dr. Adul-Kareem for his valuable contributions and support throughout this study. They would also like to express their gratitude to Dr. Ali for his valuable suggestions and comments.

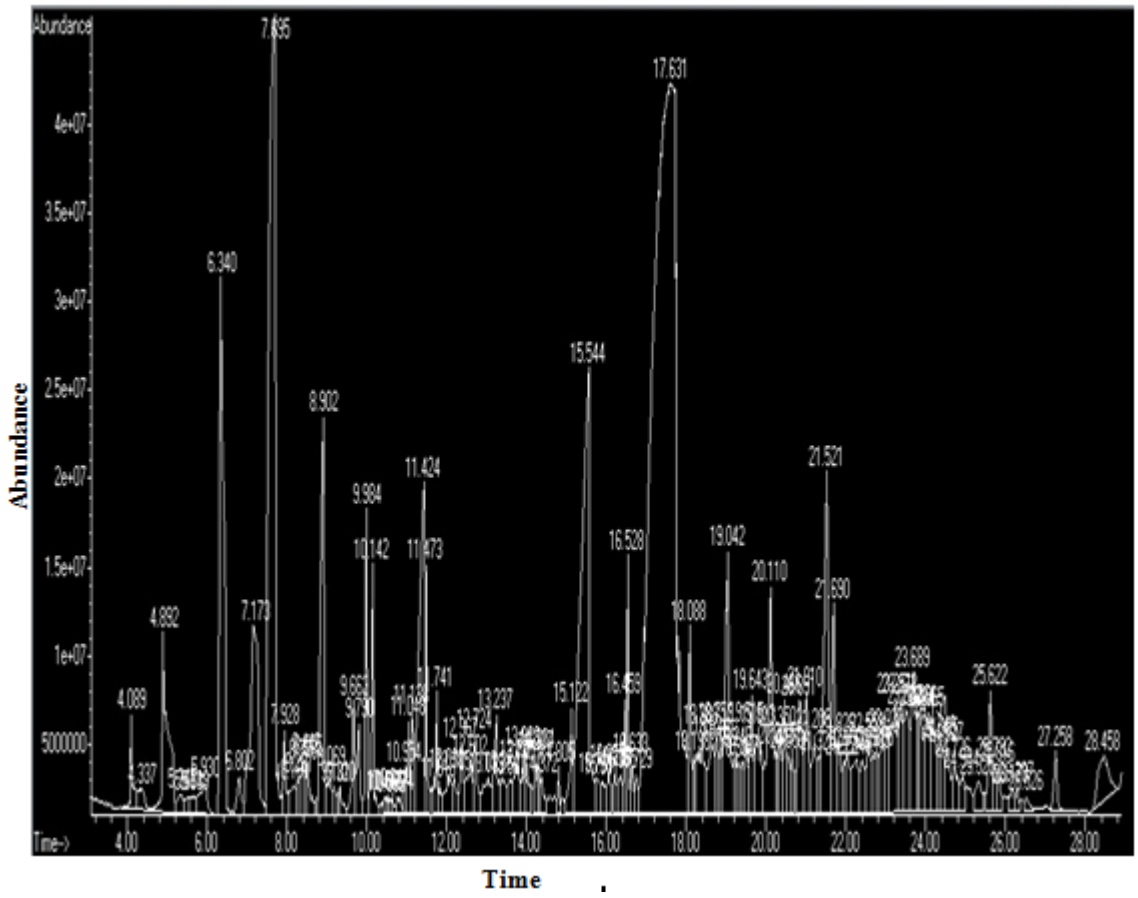


Figure 1. GC-MS chromatogram of methanolic seed extract of *Foeniculum vulgare.*

Table 2. FT-IR peak values of *Foeniculum vulgare*.

No.	Peak (Wave number cm^{-1})	Intensity	Bond	Functional group assignment	Group frequency
1	665.44	60.383	-	Unknown	-
2	719.54	64.204	C-H	Alkenes	675-995
3	889.18	74.391	C-H	Alkenes	675-995
4	1029.99	53.805	C-F stretch	Aliphatic fluoro compounds	1000-10150
5	1141.86	65.836	C-O	Alcohols, Ethers, Carboxlic acids, Esters	1050-1300
6	1244.09	70.650	C-O	Alcohols, Ethers, Carboxlic acids, Esters	1050-1300
7	1317.38	74.345	NO2	Nitro Compounds	1300-1370
8	1361.74	73.778	NO2	Nitro Compounds	1300-1370
9	1373.32	72.718	-	Unknown	-
10	1417.68	71.920	-	Unknown	-
11	1595.13	72.290	-	Unknown	-
12	1743.65	74.604	-	Unknown	-
13	2677.20	91.620	-	Unknown	-
14	2852.72	77.059	C-H	Alkanes	2850-2970
15	2922.16	70.245	C-H	Alkanes	2850-2970
16	3005.10	86.839	H-O	H-bonded H-X group	2500-3500
17	3066.82	86.670	H-O	H-bonded H-X group	2500-3500
18	3244.27	83.454	O-H	Hydrogen bonded Alcohols, Phenols	3200-3600
19	3275.13	80.640	O-H	Hydrogen bonded Alcohols, Phenols	3200-3600
20	3361.993	81.444	O-H	Hydrogen bonded Alcohols, Phenols	3200-3600

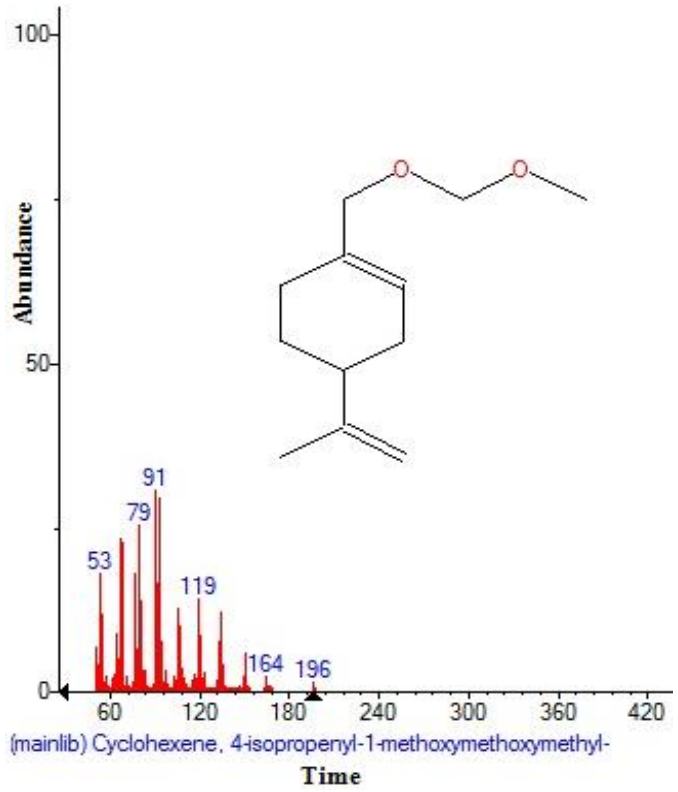


Figure 2. Structure of Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

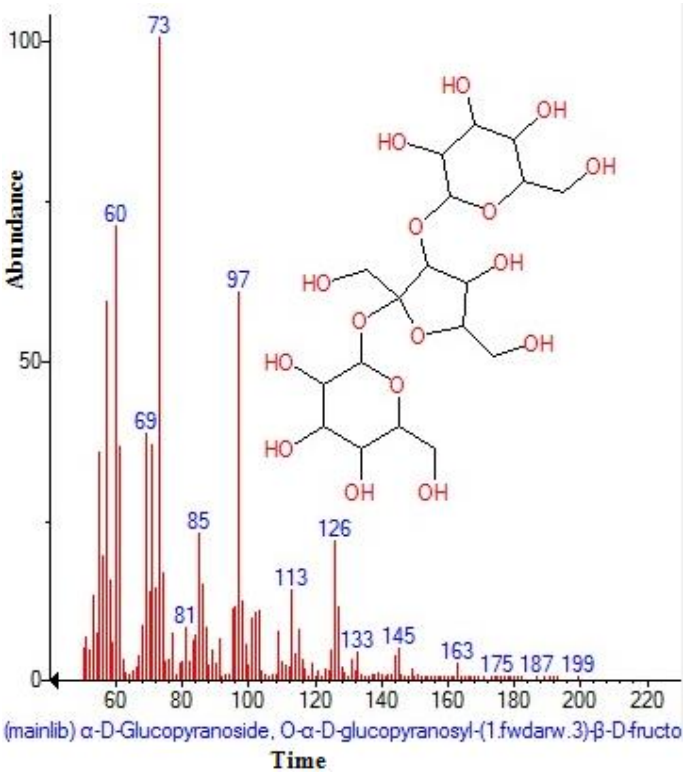


Figure 4. Structure of α-D-Glucopyranoside,O-α-D-glucopyranosyl-(1.fwdarw.3)-ß-D-fructo present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

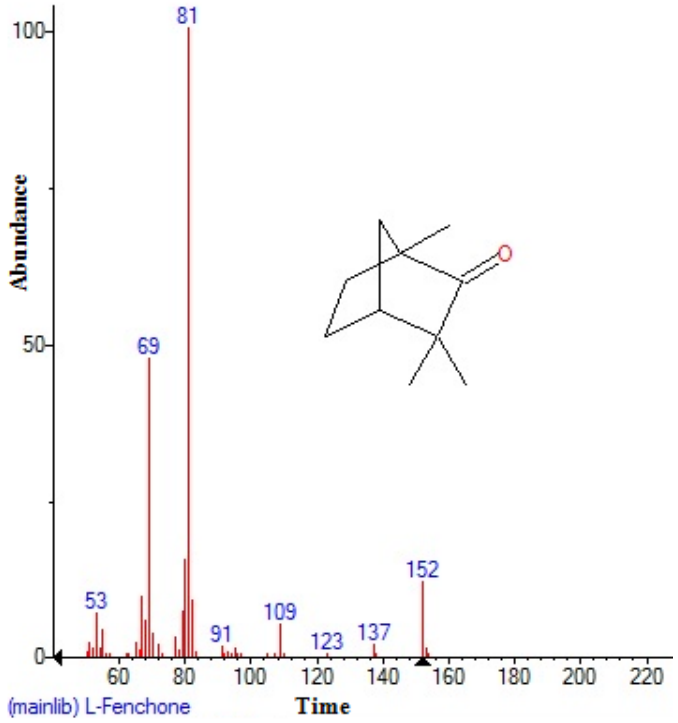


Figure 3. Structure of L-Fenchone present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

Docosatetraenoic acid , methyl ester, 1H-2,8a-Methanocyclopenta[a]cyclopropa[e]cyclodecen-11-one,1, 9-Octadecenamide ,(Z), dl-3Beta-hydroxy-d-homo-18-nor-5alpha,8alpha,14beta-androst-13(1), dl-3Beta-hydroxy-d-homo-18-nor-5alpha,8alpha,14beta-androst-13(1), 9-Octadecenoic acid (Z)-,2-hydroxy-1-(hydroxymethyl)ethyl ester, 5aH-3a,12-methano-1H-cyclopropa [5´,6´]cyclodeca[1´,2´:1,5]cyclo, 1,2-Benzenedicarboxylic acid, bis(8-methylnonyl)ester, (22S)-21-Acetoxy-6α,11ß-dihydroxy-16α,17α-propylmethylene-dioxyp, Oxiraneoctanoic acid, 3-octyl-,methyl ester, 1,5-Bis(4-methoxyphenyl)bicyclo[3.2.0]heptane, 1,2-Benzenedicarboxylic acid , bis(8-methylnonyl)ester, (22S)-21-Acetoxy-6α,11ß-dihydroxy-16α,17α-propylmethylene dioxyp, Oxiraneoctanoic acid, 3-octyl-,methyl ester, 1,5-Bis(4-methoxyphenyl)bicyclo[3.2.0]heptane, Ingol 12-acetate, Isoquinoline,1-[3-methoxy-5-hydroxybenzyl]-1,2,3,4,5,8-hexahydro, Cholestan-3-one, cyclic 1,2-ethanediyl aetal,(5ß), 2,24a,6a,8a,9,12b,14a-Octamethyl-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,1, and Undeca -3,4-diene-2,10-dione,5,6,6-trimethyl (Figures 2 to 59). The FTIR analysis of *F. vulgare* seeds proved the presence of alkenes, aliphatic fluoro compounds, alcohols, ethers, carboxlic acids, esters, nitro compounds, alkanes,

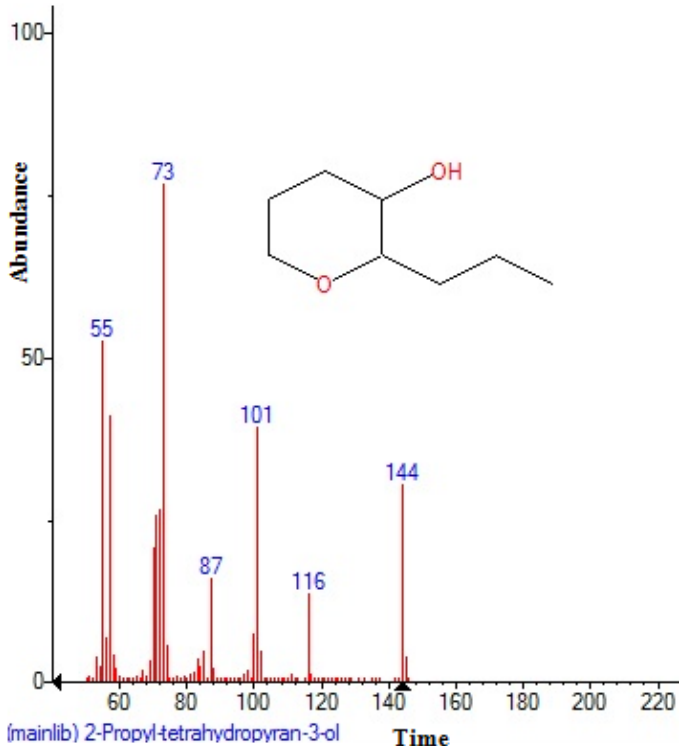


Figure 5. Structure of 2-Propyl-tetrahydropyran-3-ol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

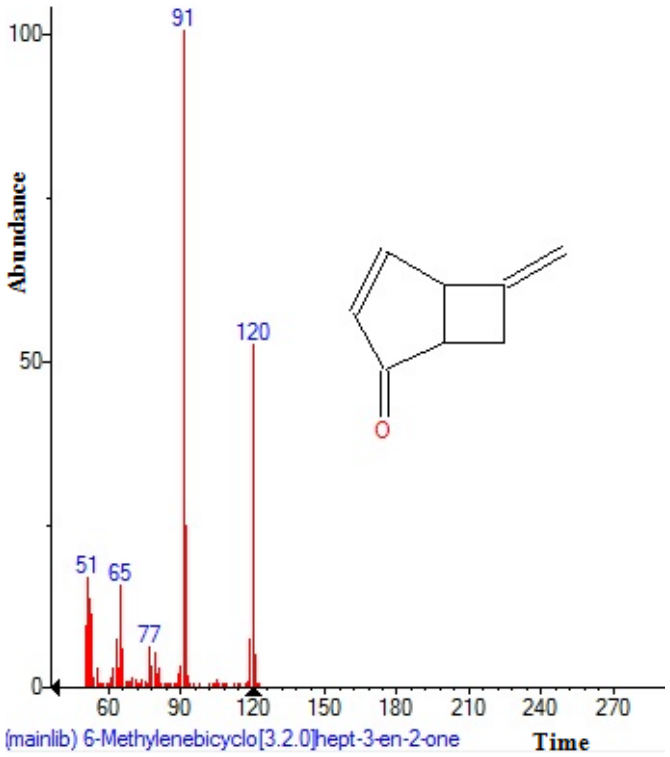


Figure 7. Structure of 6-Methylenebicyclo[3.2.0]hept-3-en-2-one present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

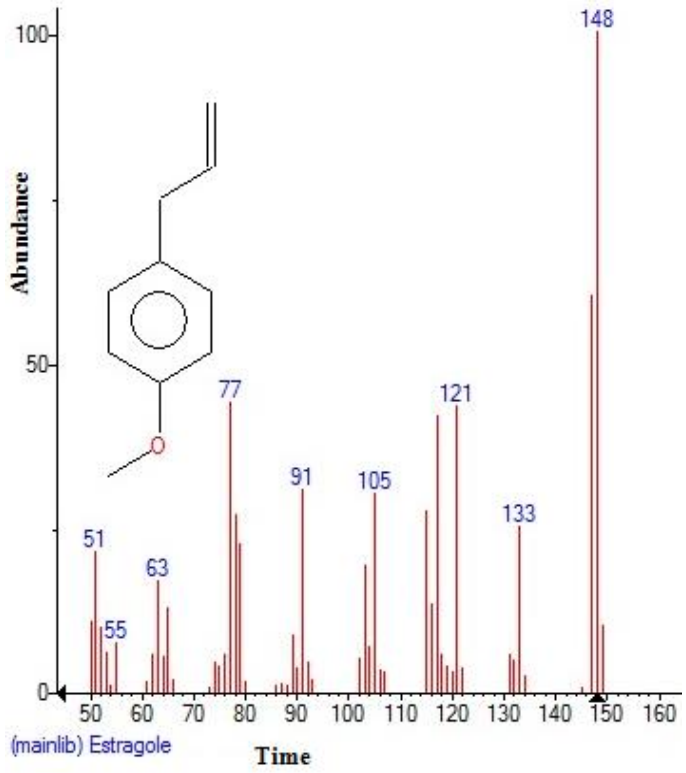


Figure 6. Structure of Estragole present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

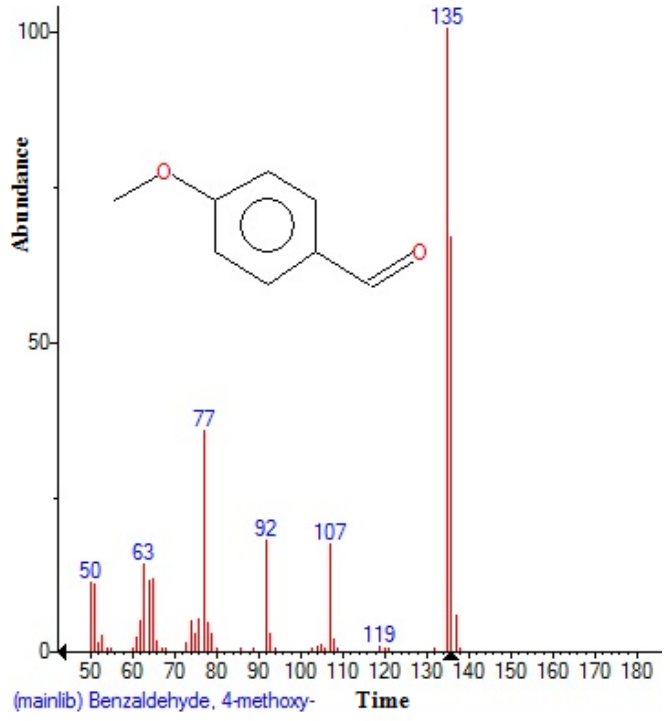


Figure 8. Structure of Benzaldehyde ,4-methoxy present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

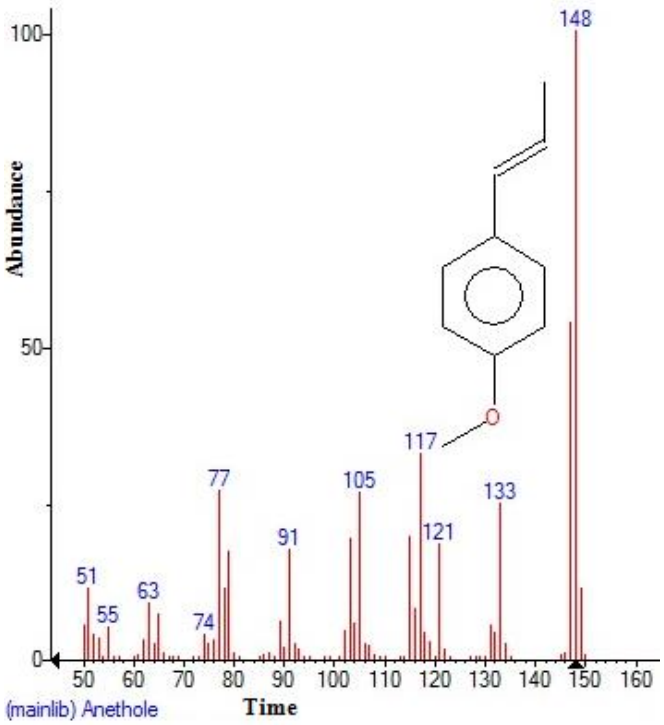


Figure 9. Structure of Anethole present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

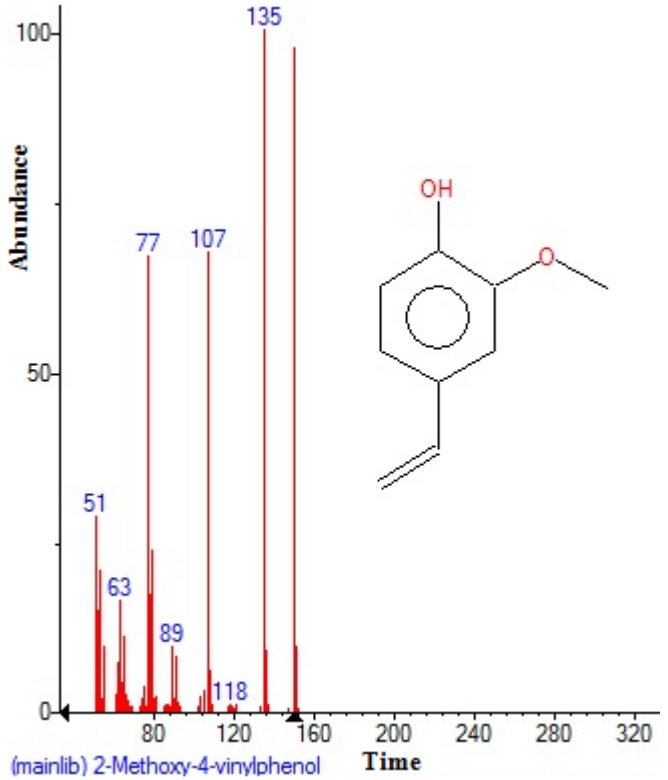


Figure 11. Structure of 2-Methoxy-4-vinylphenol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

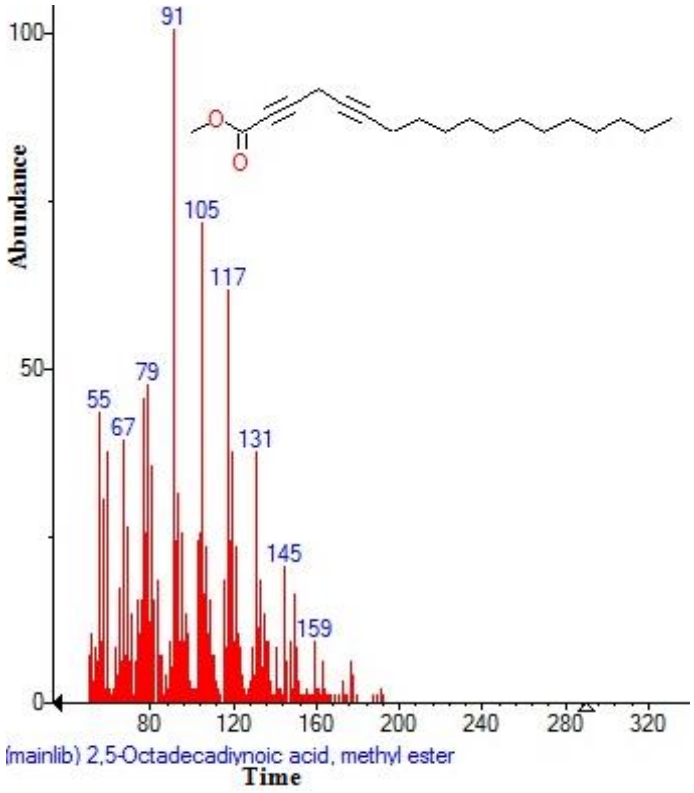


Figure 10. Structure of 2,5-Octadecadiynoic acid , methylester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

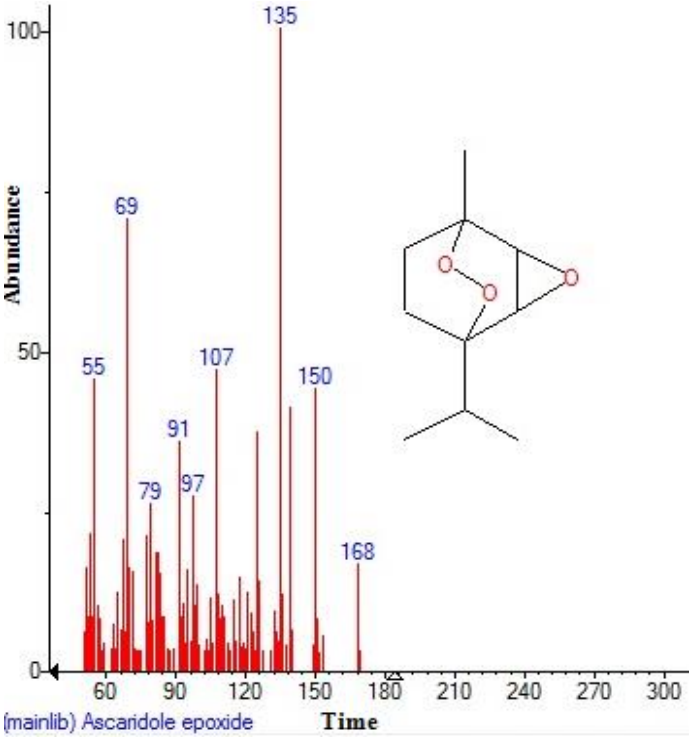


Figure 12. Structure of Ascaridole epoxide present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

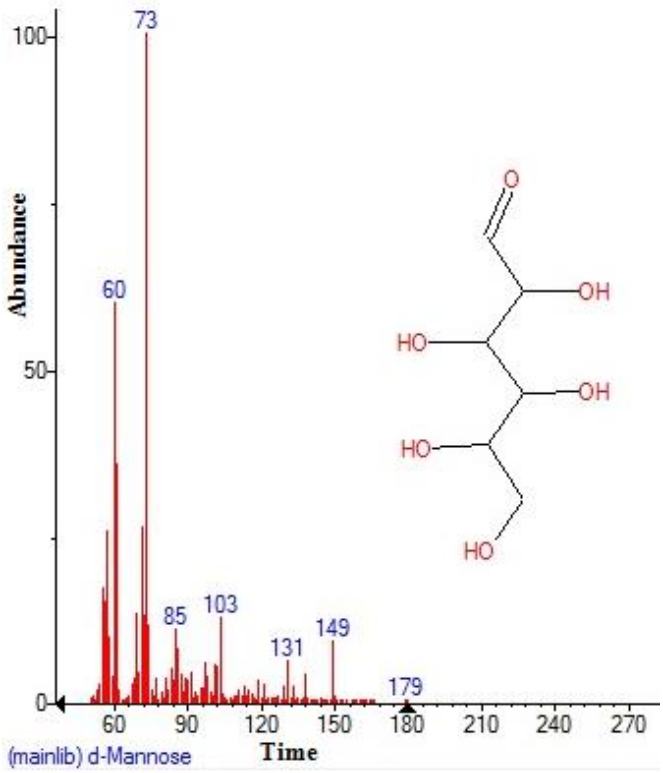


Figure 13. Structure of d-Mannose present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

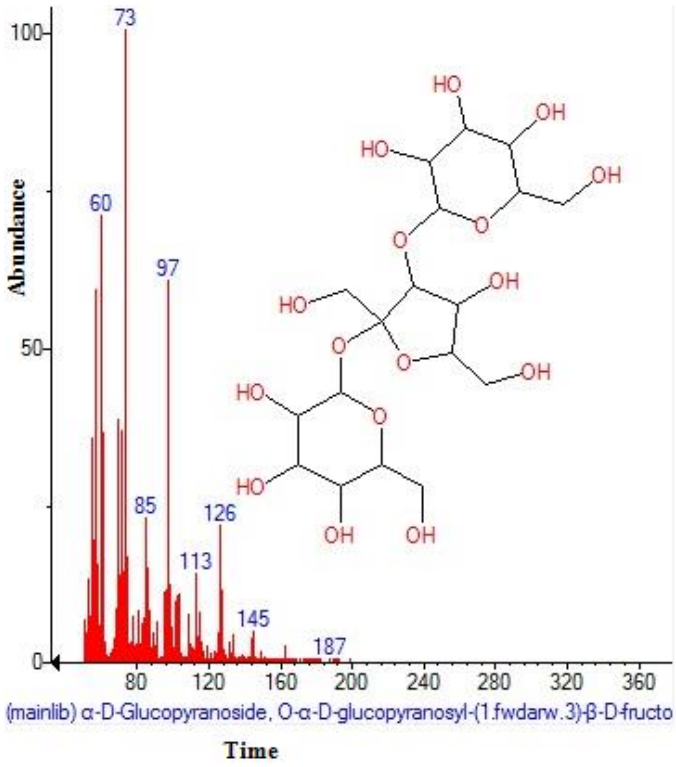


Figure 15. Structure of α-D-Glucopyranoside, O-α-D-glucopyranosyl-(1.fwdarw.3)-ß-D-fructo present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

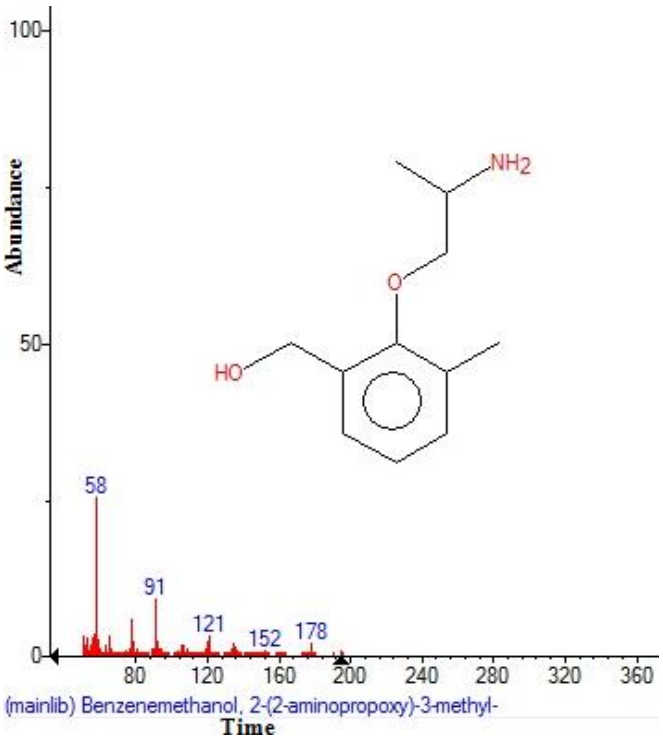


Figure 14. Structure of Benzenemethanol , 2-(2-aminopropoxy)-3-methyl present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

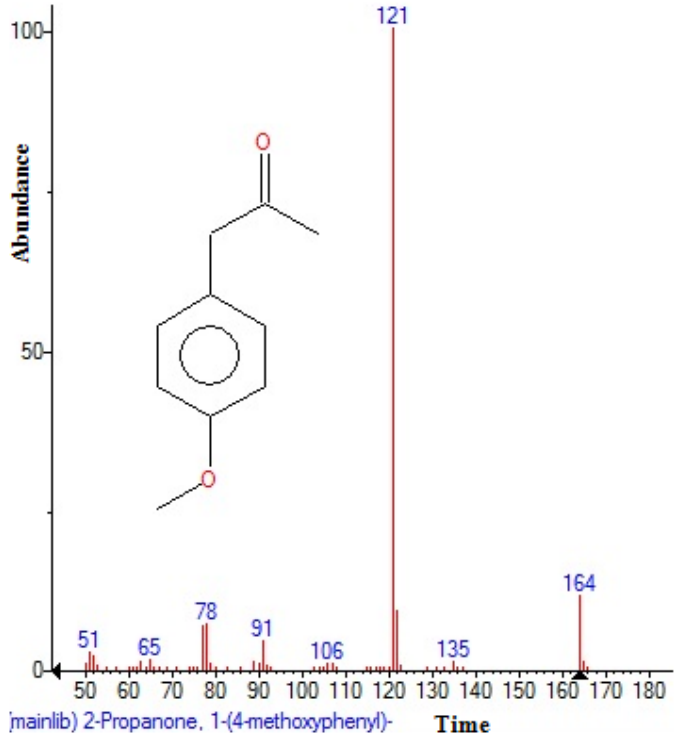


Figure 16. Structure of 2-Propanone, 1-(4-methoxyphenyl) present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

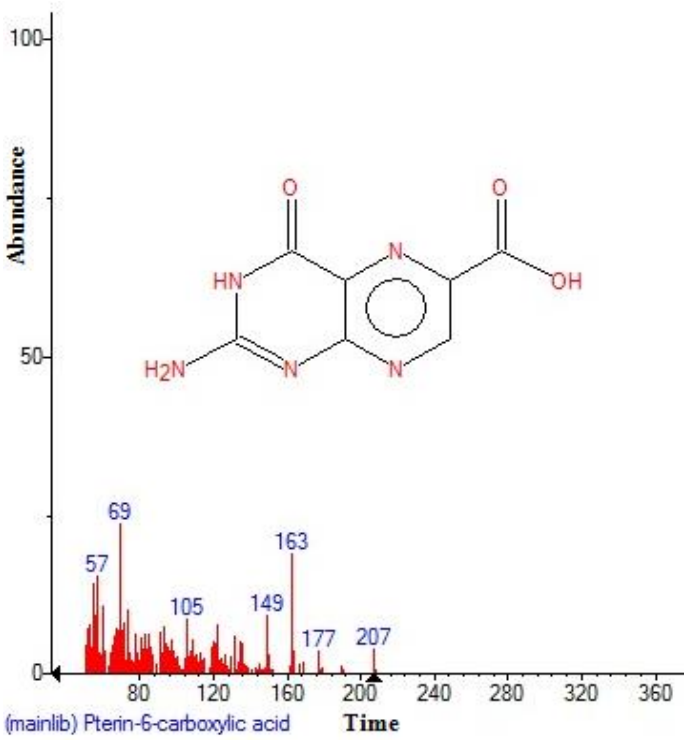


Figure 17. Structure of Pterin -6-carboxylic acid present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

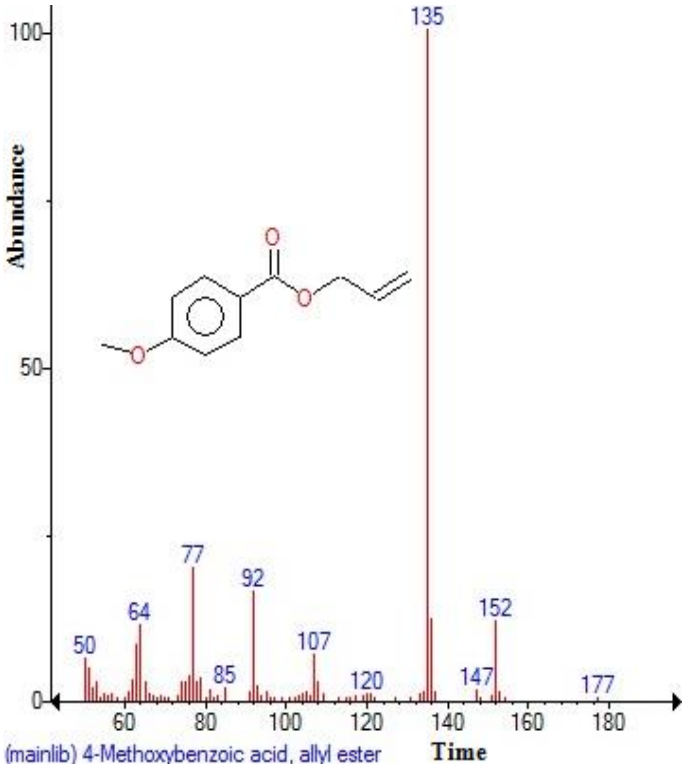


Figure 19. Structure of 4-Methoxybenzoic acid, allyl ester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

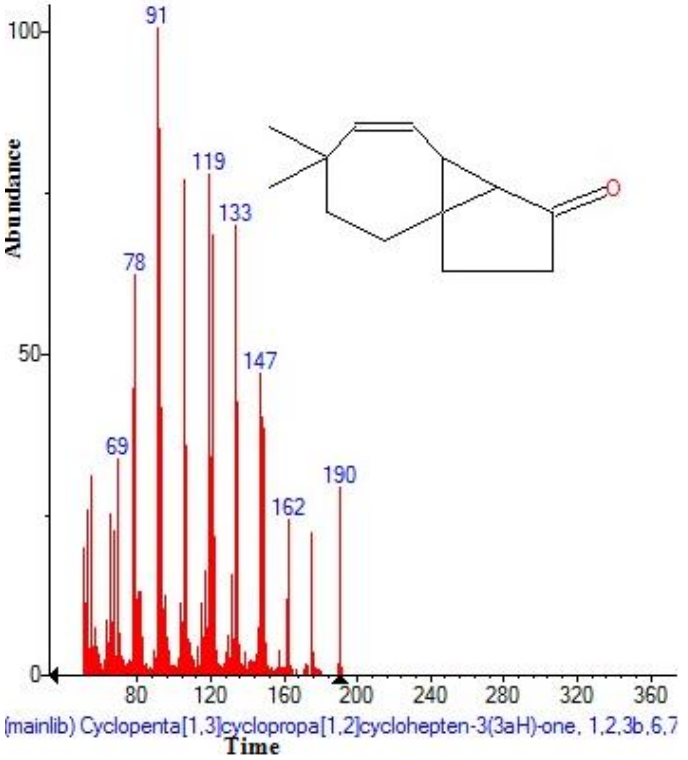


Figure 18. Structure of Cyclopenta [1,3]cyclopropa[1,2]cyclohepten-3(3aH)-one,1,2,3b,6,7 present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

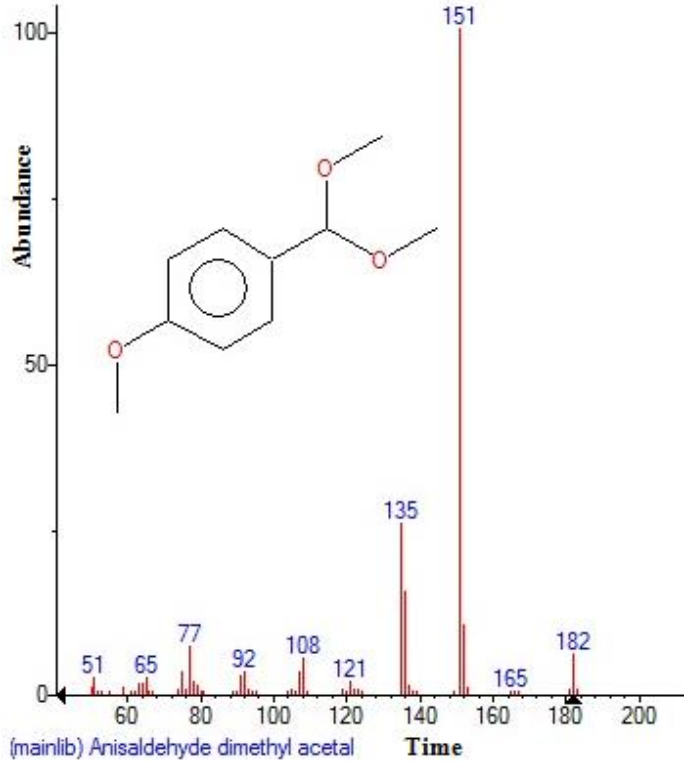


Figure 20. Structure of Arisaldehyde dimethyl acetal present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

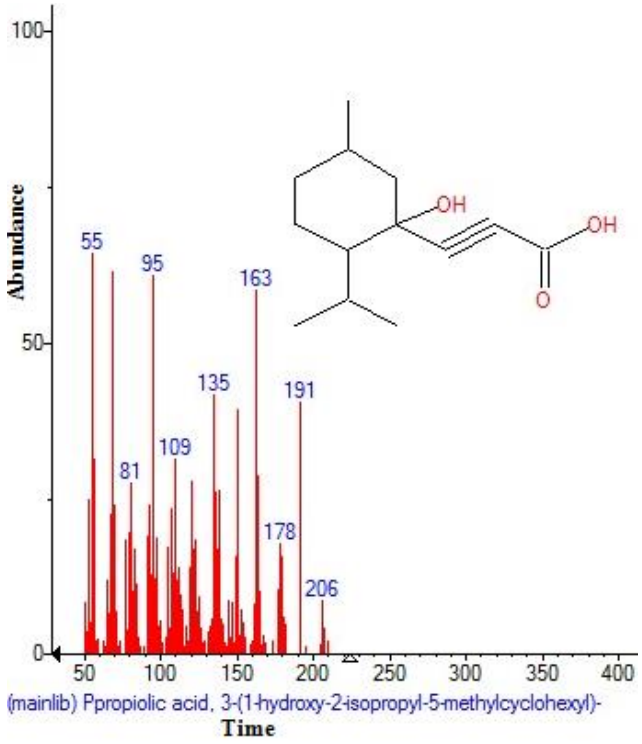


Figure 21. Structure of Propiolic acid, 3-(1-hydroxy-2-isopropyl-5-methylcyclohexyl) present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

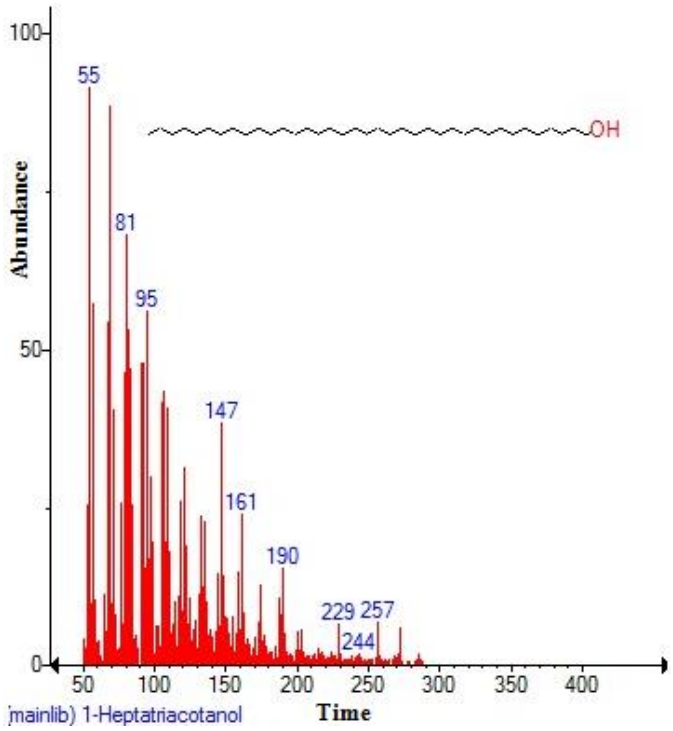


Figure 23. Structure of 1-Heptatriacotanol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

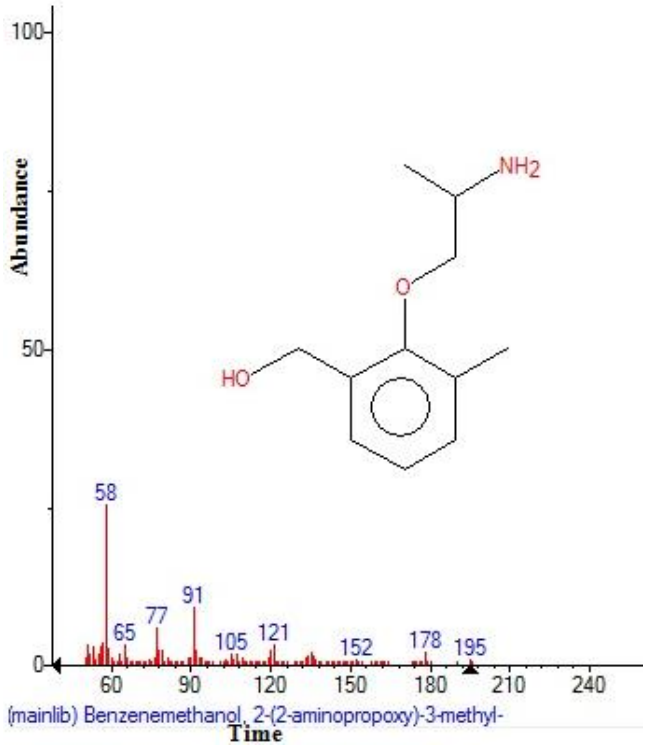


Figure 22. Structure of Benzenemethanol,2-(2-aminopropoxy)-3-methyl present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

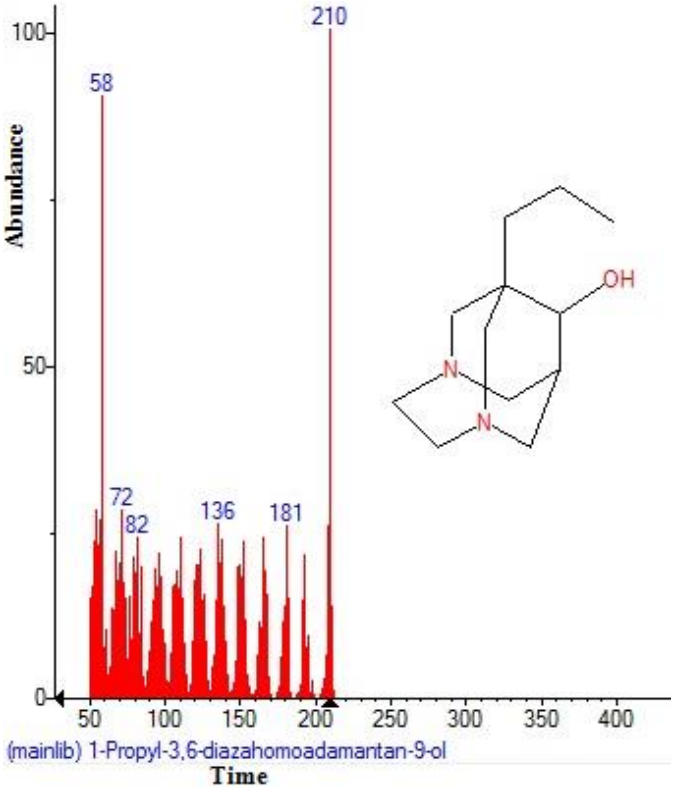


Figure 24. Structure of 1-propyl-3,6-diazahomoadamantan-9-ol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

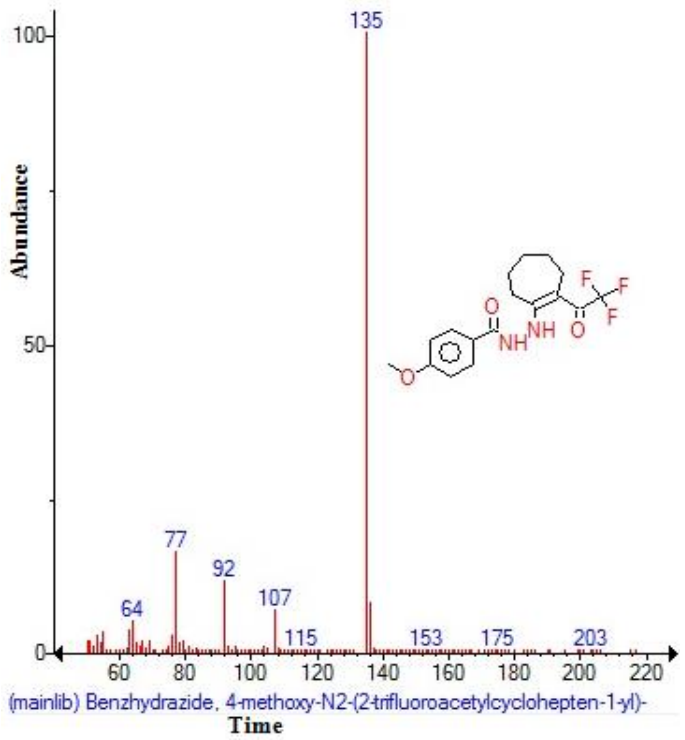


Figure 25. Structure of Benzhydrazide, 4-methoxy-N2-(2-trifluoroacetylcyclohepten-1-yl) present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

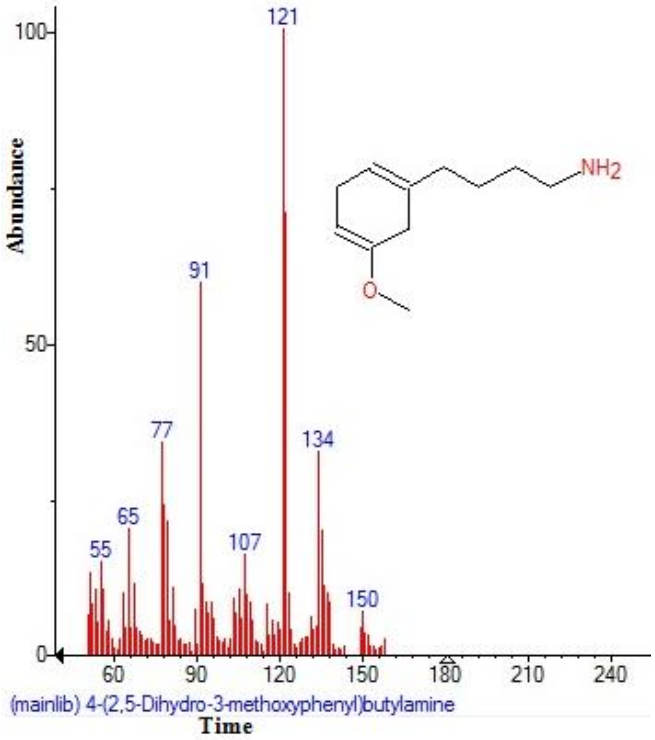


Figure 26. Structure of 4-(2,5-Dihydro-3-methoxyphenyl)butylamine present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

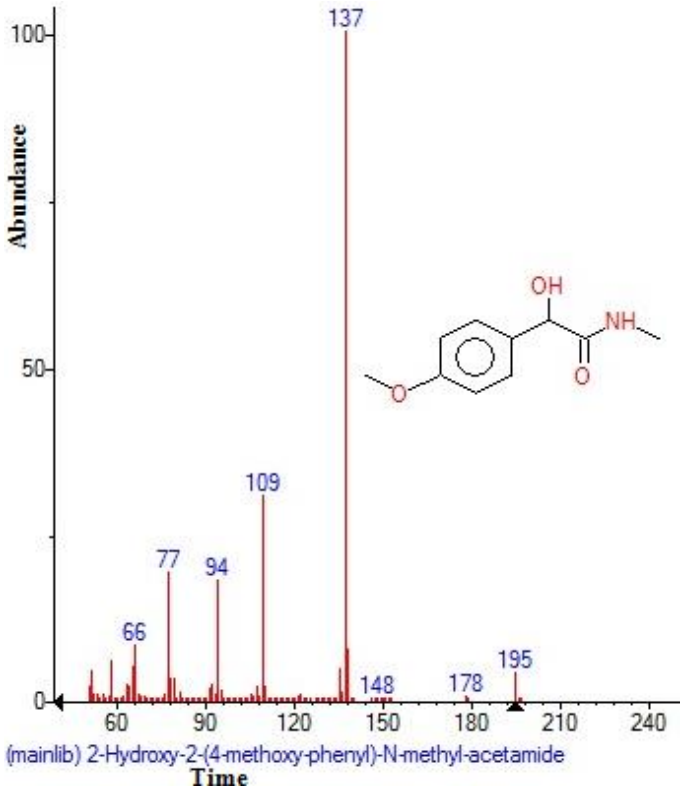


Figure 27. Structure of 2-Hydroxy-2-(4-methoxy-phenyl)-N-methyl – acetamide present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

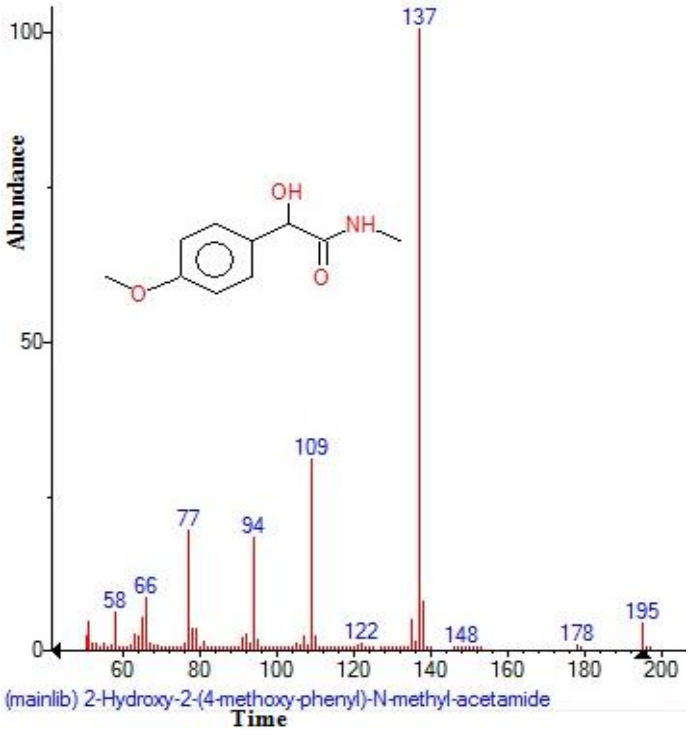


Figure 28. Structure of 2-Hydroxy-2-(4-methoxy-phenyl)-N-methyl-acetamide present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

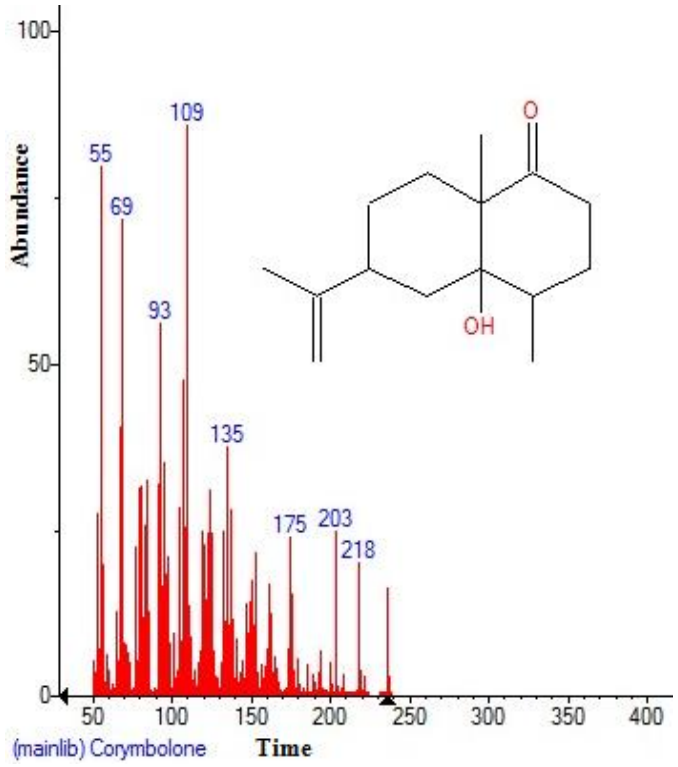


Figure 29. Structure of Corymbolone present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

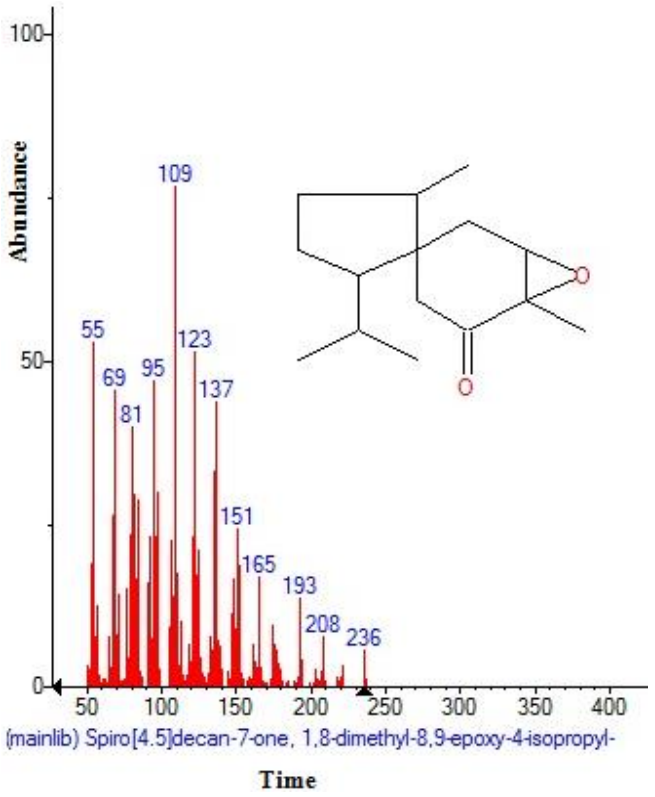


Figure 31. Structure of Spiro[4.5]decan-7-one,1,8-dimethyl-8,9-epoxy-4-isopropyl present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

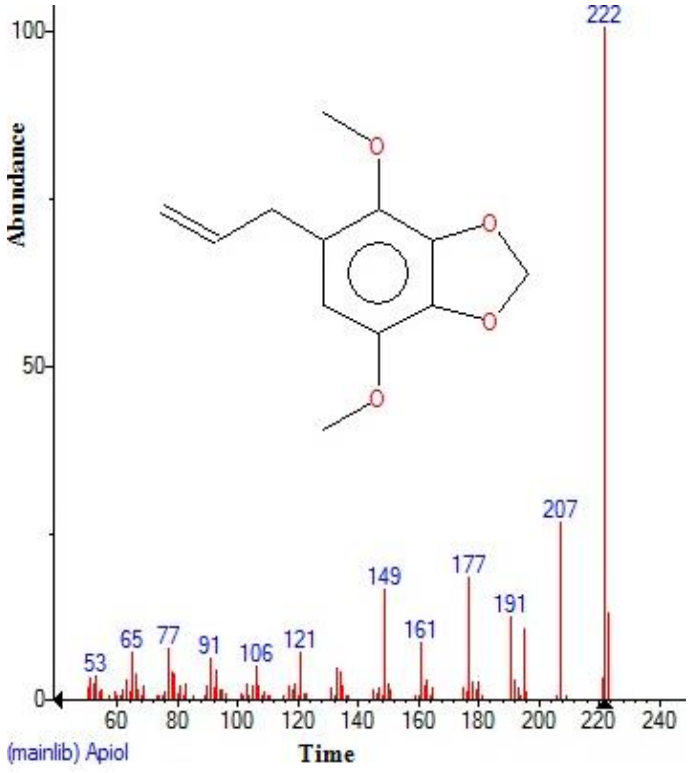


Figure 30. Structure of Apiol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

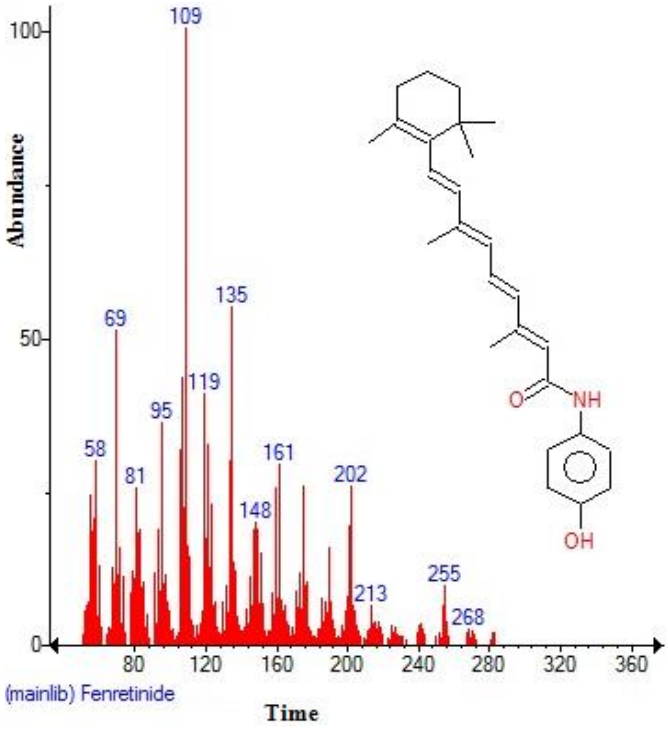


Figure 32. Structure of Fenretinide present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

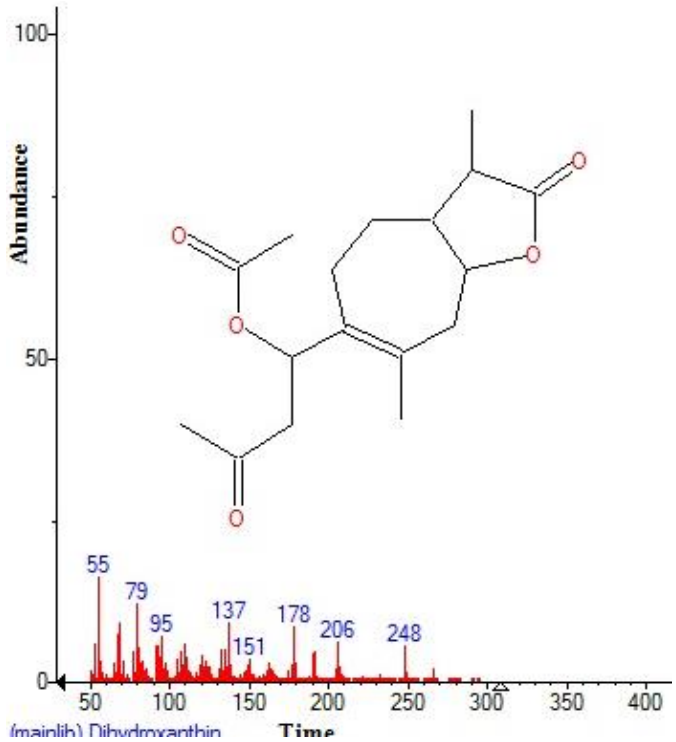


Figure 33. Structure of Dihydroxanthin present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

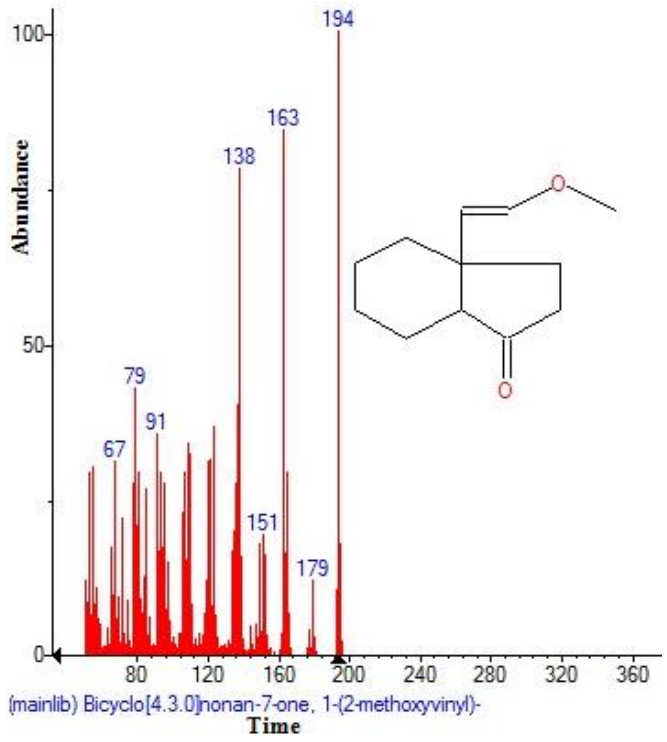


Figure 35. Structure of Bicyclo[4.3.0]nonan-7-one,1-(2-methoxyvinyl) present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

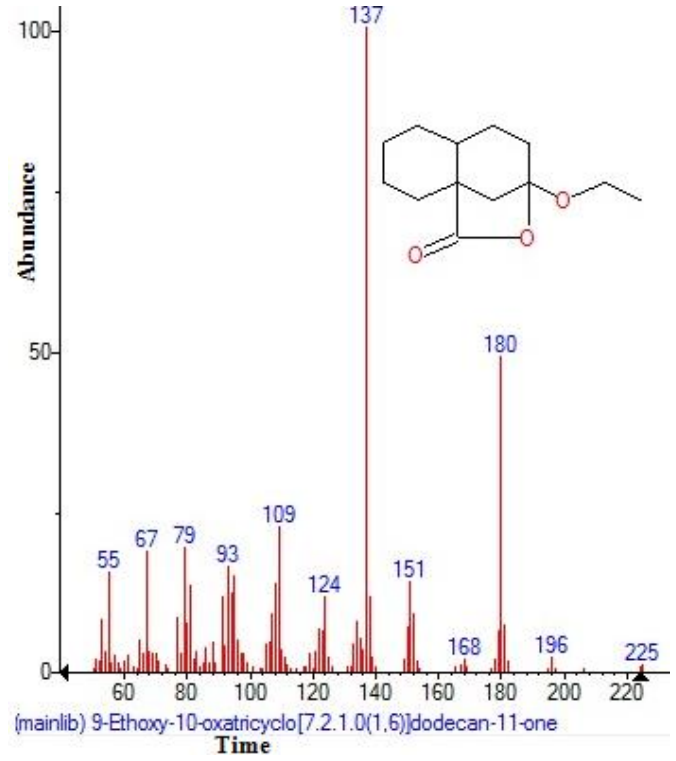


Figure 34. Structure of 9-Ethoxy-10-oxatricyclo[7.2.1.0(1,6)]dodecan-11-one present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

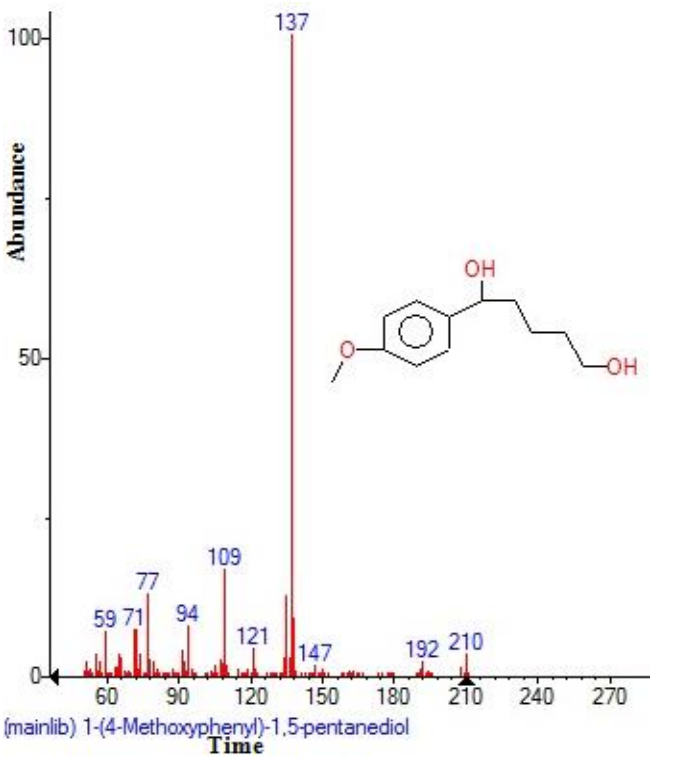


Figure 36. Structure of 1-(4-methoxyphenyl)-1,5-pentanediol present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

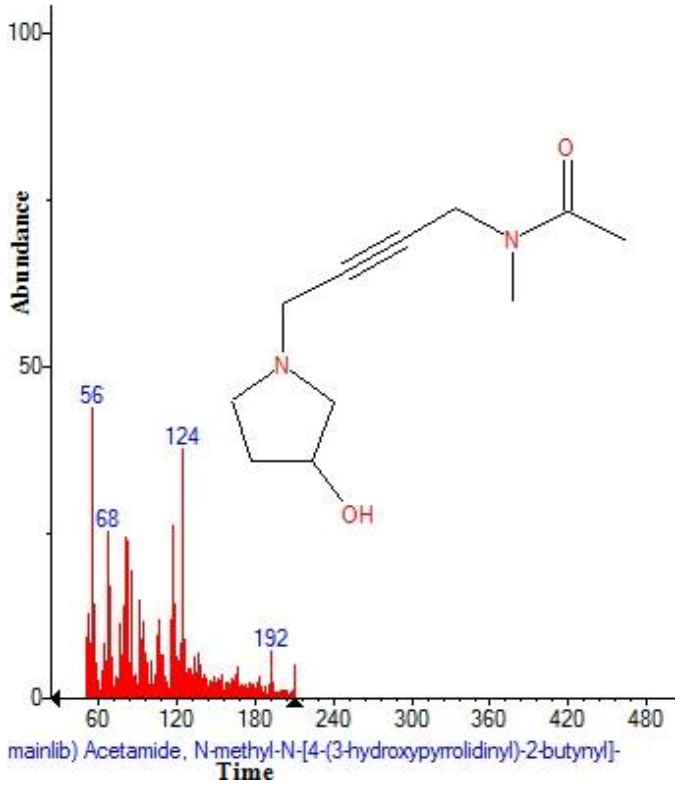


Figure 37. Structure of Acetamide,N-methyl-N-[4-(3-hydroxypyrrolidinyl)-2-butynyl] present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

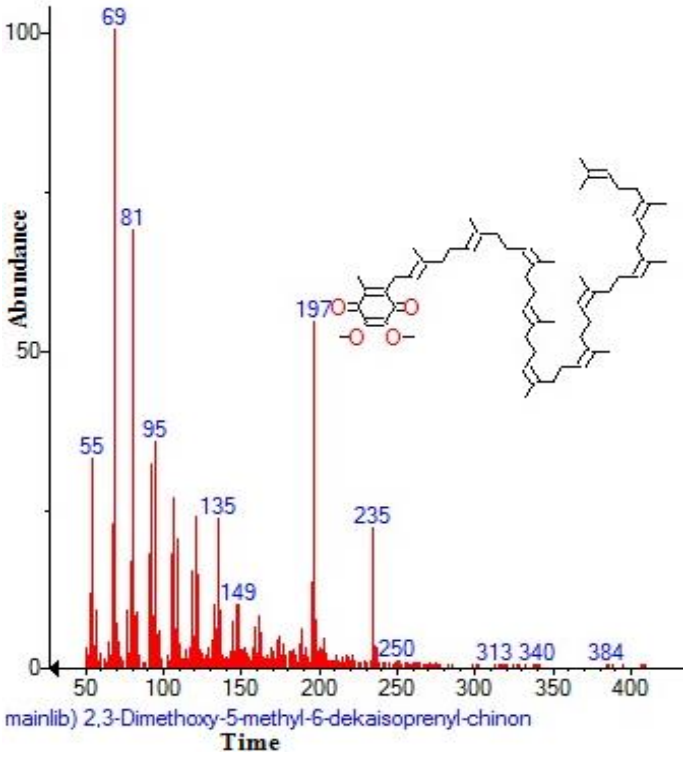


Figure 39. Structure of 2,3-Dimethoxy-5-methyl-6- decaisoprenyl-chinon present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

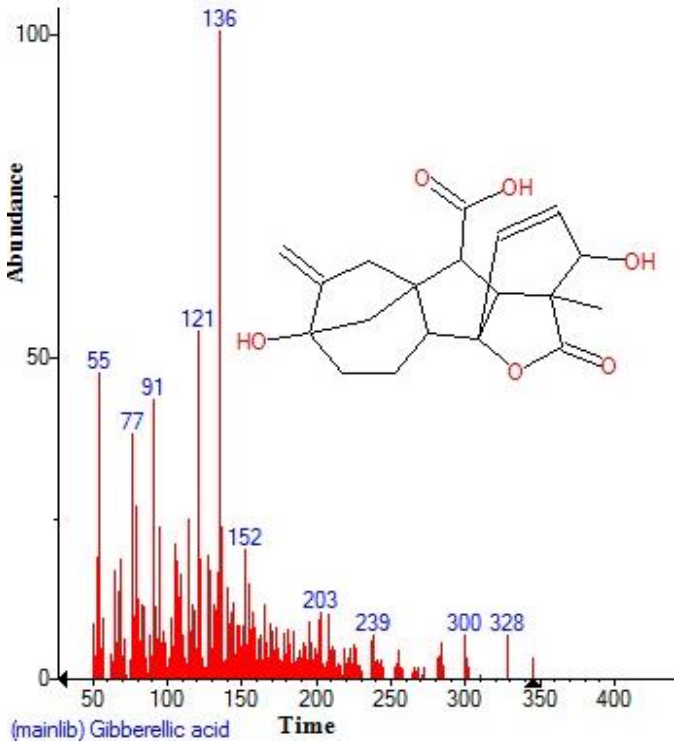


Figure 38. Structure of Gibberellic acid present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

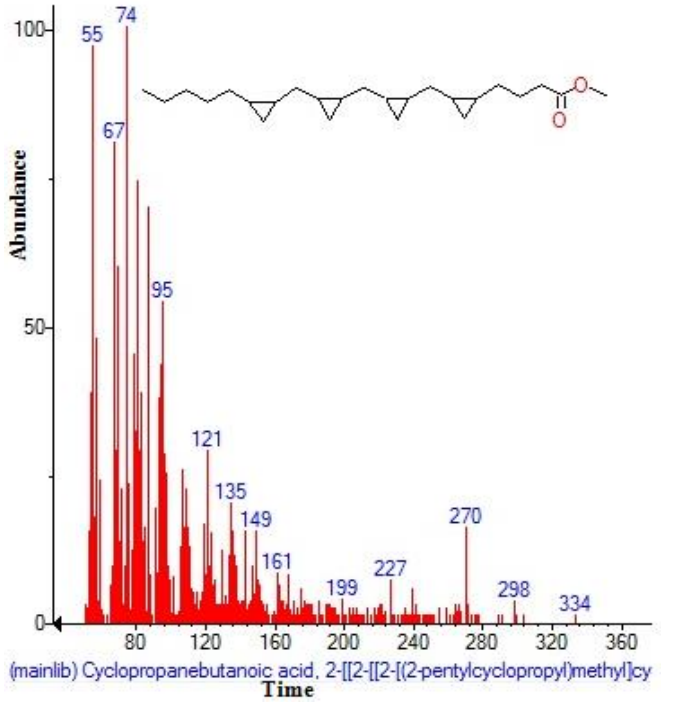


Figure 40. Structure of Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cy present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

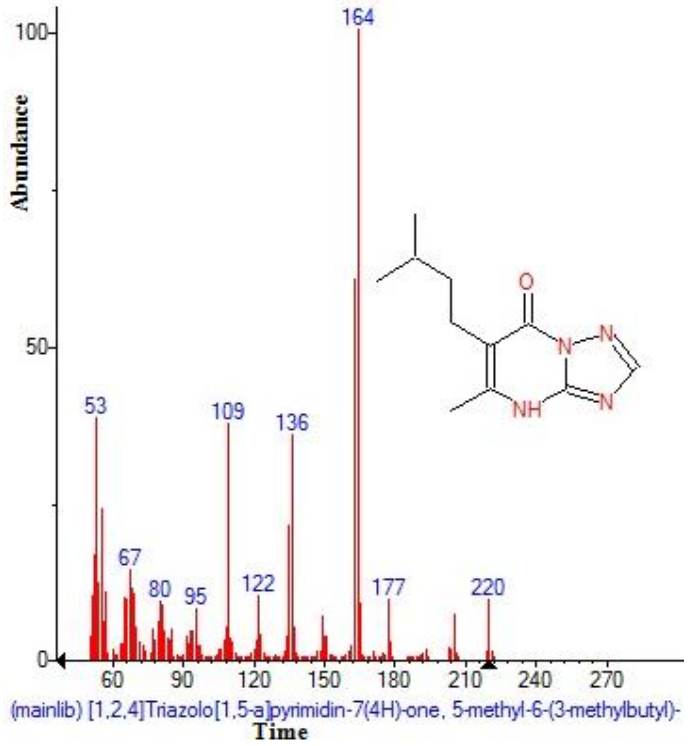


Figure 41. Structure of [1,2,4]Triazolo[1,5-a]pyrimidin-7(4H)-one,5-methyl-6-(3-methylbutyl) present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

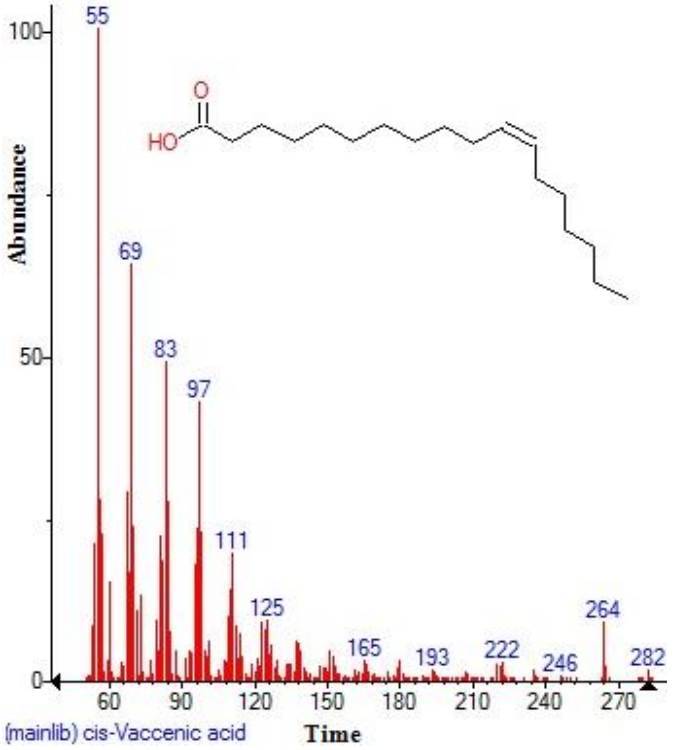


Figure 43. Structure of Cis-Vaccenic acid present in the methanolic seeds extract of *F.vulgare* using GC-MS analysis.

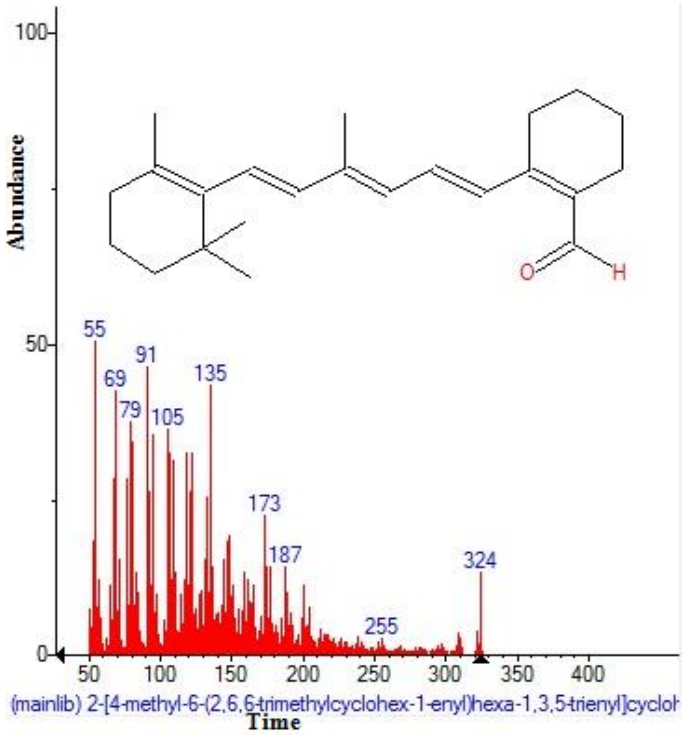


Figure 42. Structure of 2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclo present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

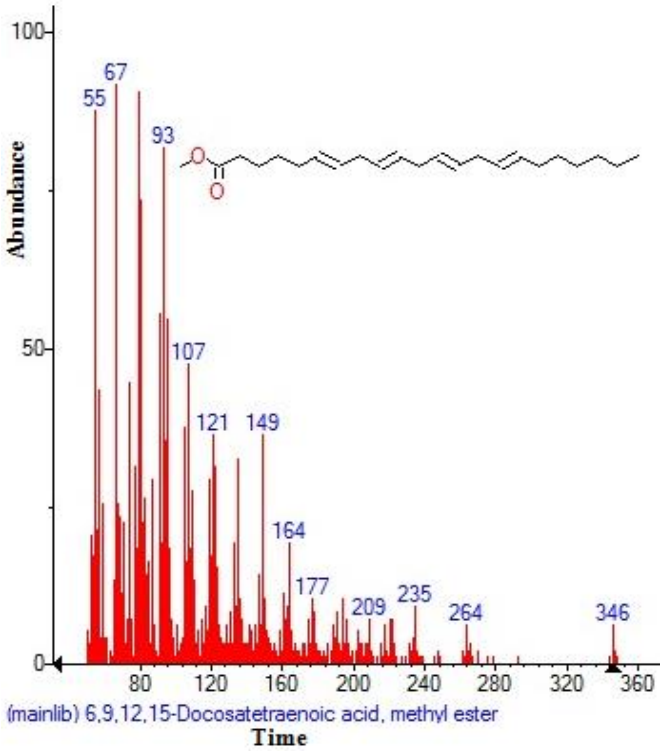


Figure 44. Structure of 6,9,12,15-Docosatetraenoic acid, methyl ester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

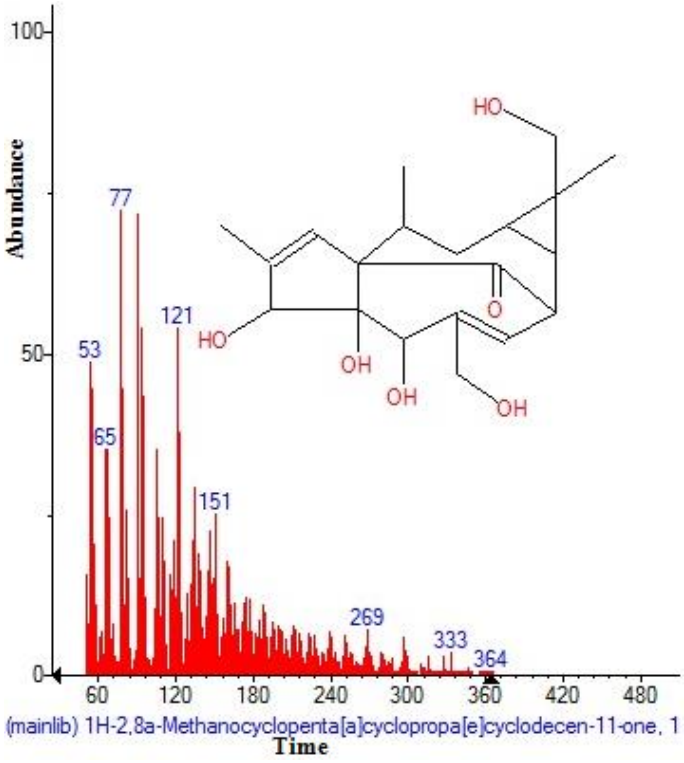


Figure 45. Structure of 1H-2,8a-Methanocyclopenta[a]cyclopropa[e]cyclodecen-11-one,1 present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

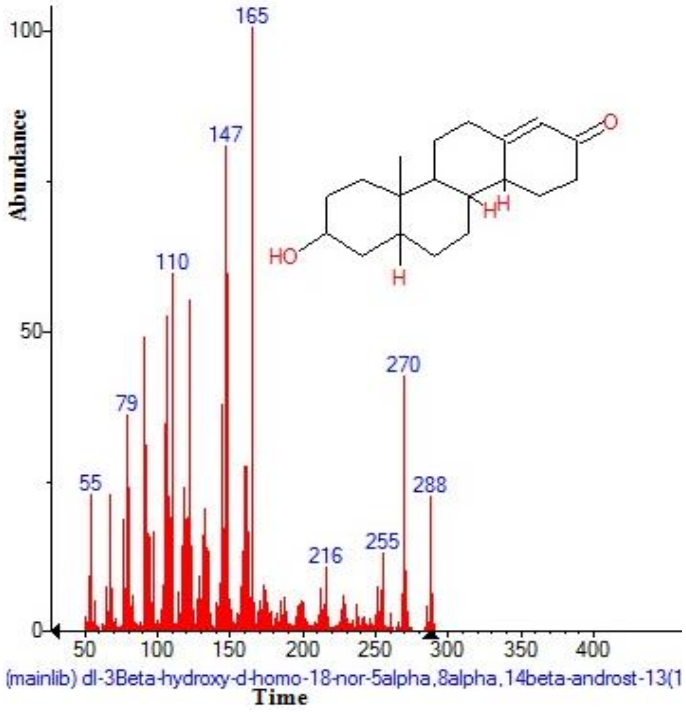


Figure 47. Structure of dl-3Beta-hydroxy-d-homo-18-nor-5alpha,8alpha,14beta-androst-13(1) present in the methanolic seeds extract of *Foeniculum vulgare* using GC-MS analysis.

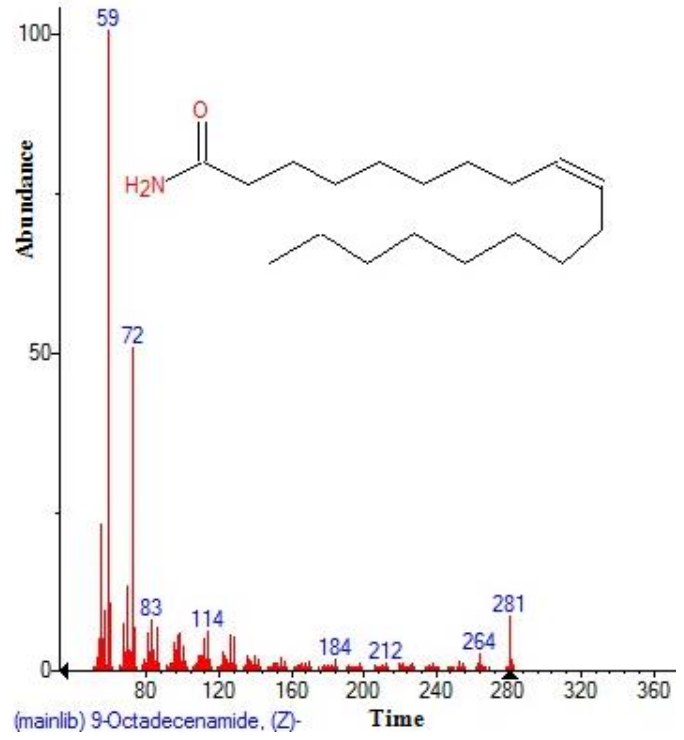


Figure 46. Structure of 9-Octadecenamide, (Z) present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

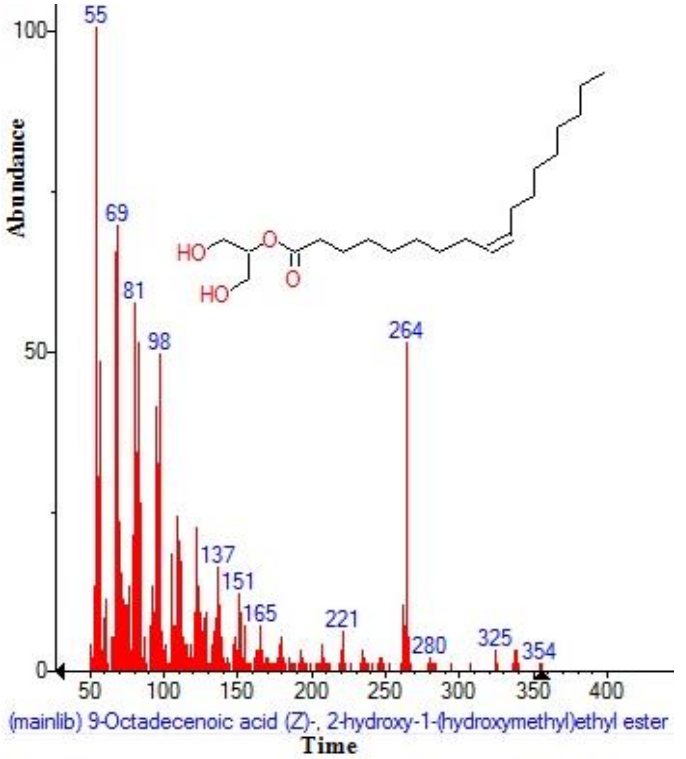


Figure 48. Structure of 9-Octadecenoic acid (Z)-,2-hydroxy-1-(hydroxymethyl)ethyl ester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

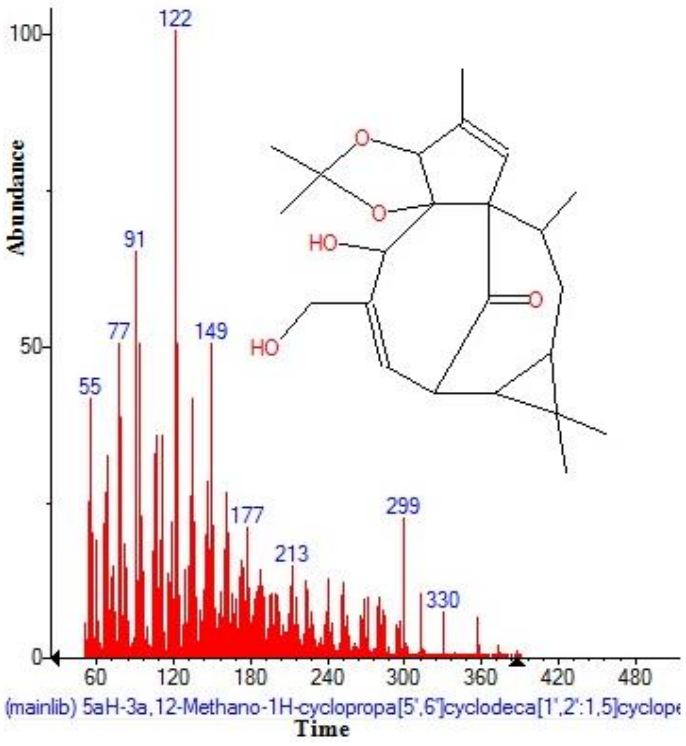


Figure 49. Structure of 5aH-3a,12-methano-1H-cyclopropa[5´,6´]cyclodeca[1´,2´:1,5]cyclo present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

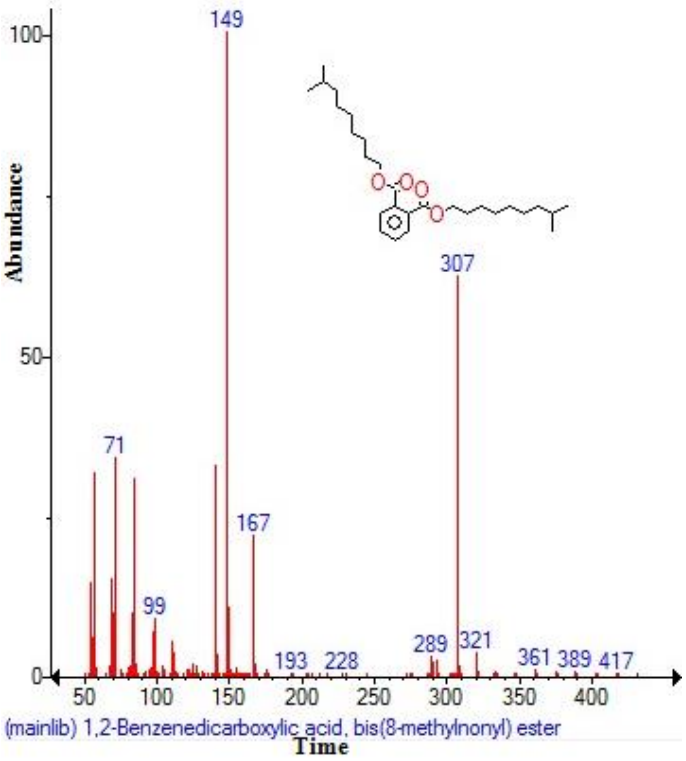


Figure 51. Structure of 1,2-Benzenedicarboxylic acid, bis(8-methylnonyl)ester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

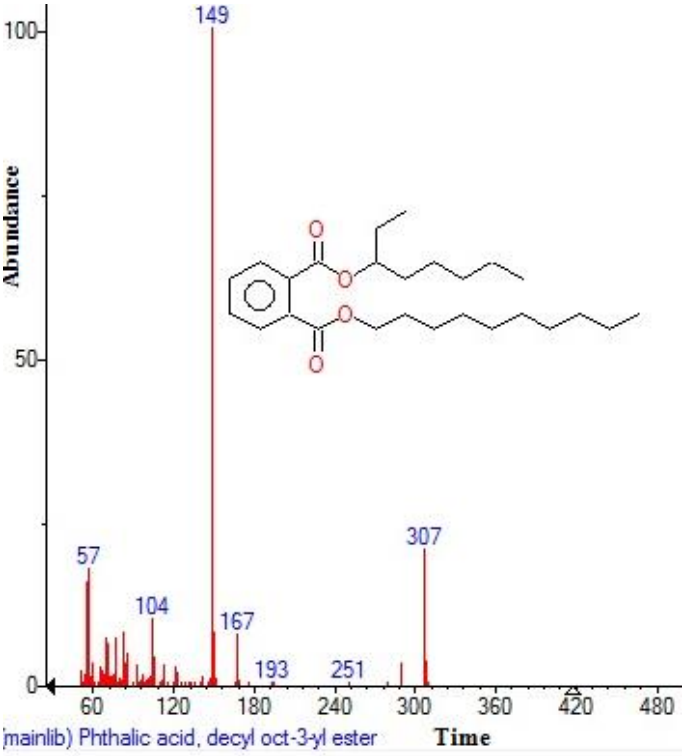


Figure 50. Structure of Phthalic acid, decyl oct-3-ylester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

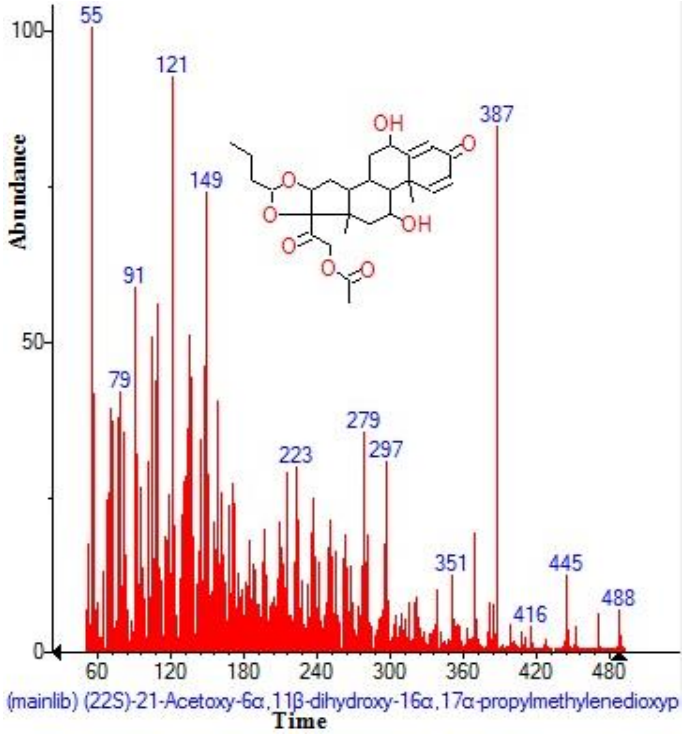


Figure 52. Structure of (22S)-21-Acetoxy-6α,11ß-dihydroxy-16α,17α-propylmethylenedioxyp present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

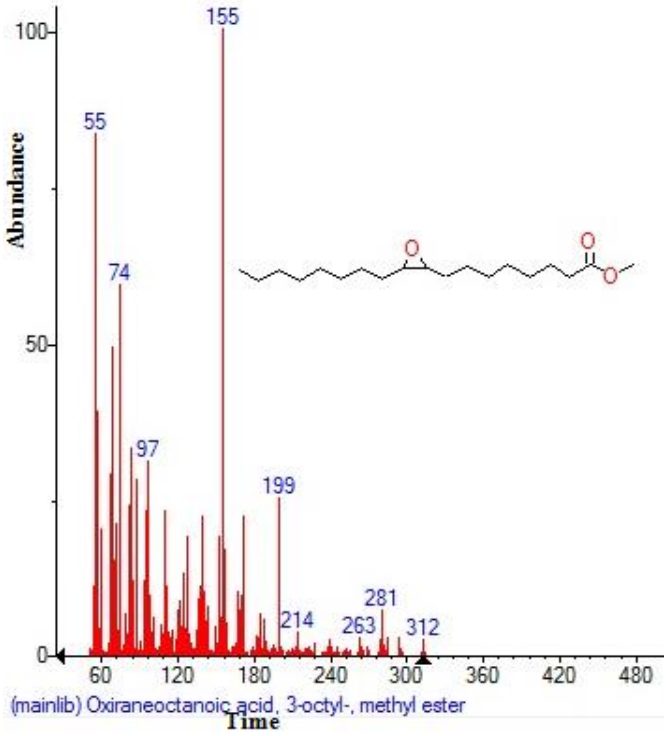


Figure 53. Structure of Oxiraneoctanoic acid, 3-octyl-,methyl ester present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

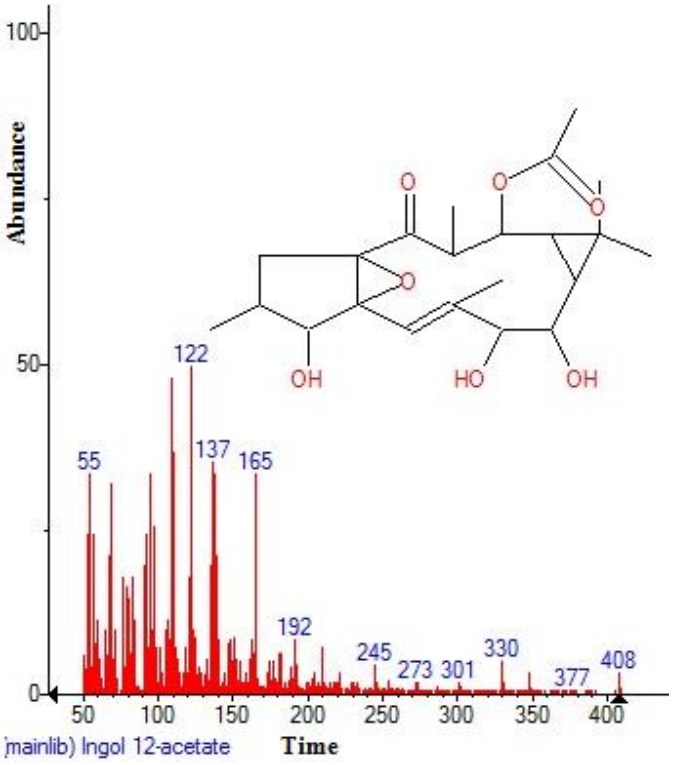


Figure 55. Structure of Ingol 12-acetate present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

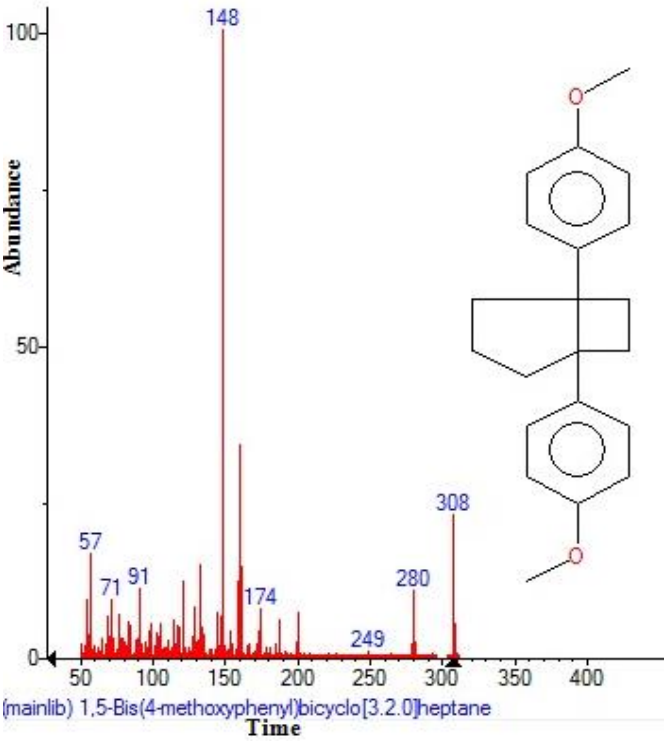


Figure 54. Structure of 1,5-Bis(4-methoxyphenyl)bicyclo[3.2.0]heptane present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

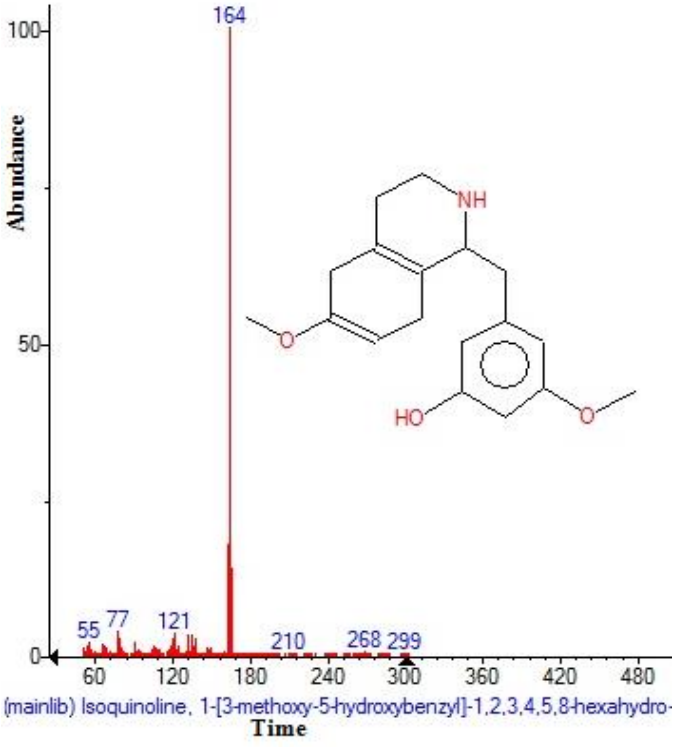


Figure 56. Structure of Isoquinoline,1-[3-methoxy-5-hydroxybenzyl]-1,2,3,4,5,8-hexahydro present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

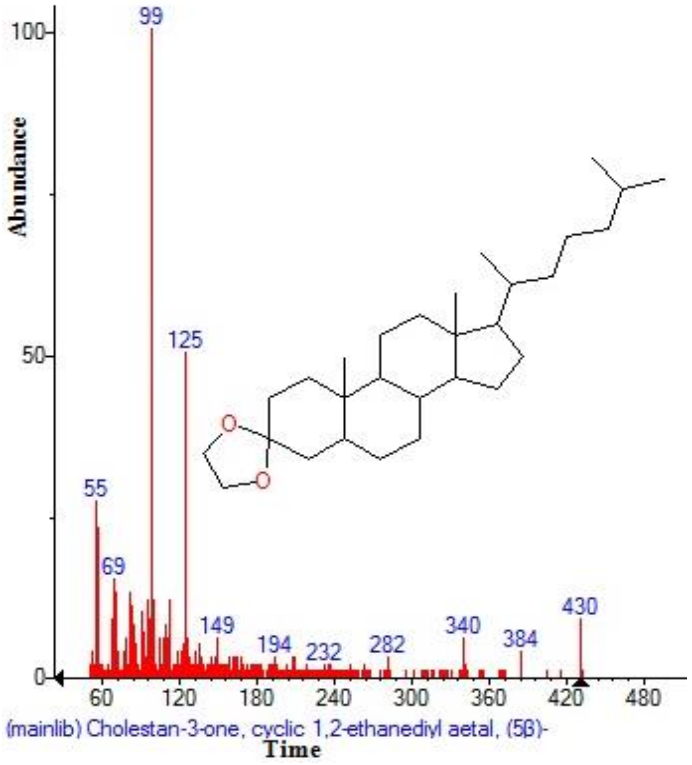


Figure 57. Structure of Cholestan-3-one , cyclic 1,2-ethanediyl aetal,(5ß) present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

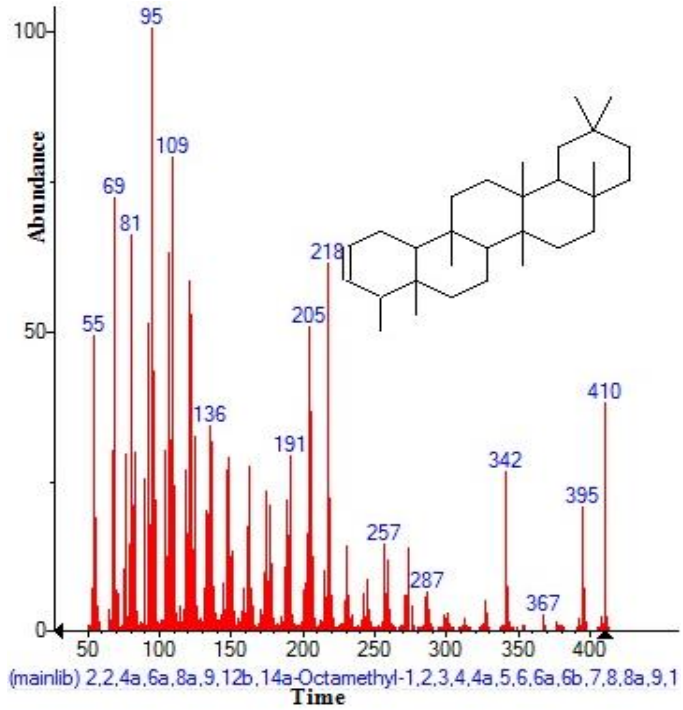


Figure 58. Structure of 2,24a,6a,8a,9,12b,14a-Octamethyl-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,1 present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

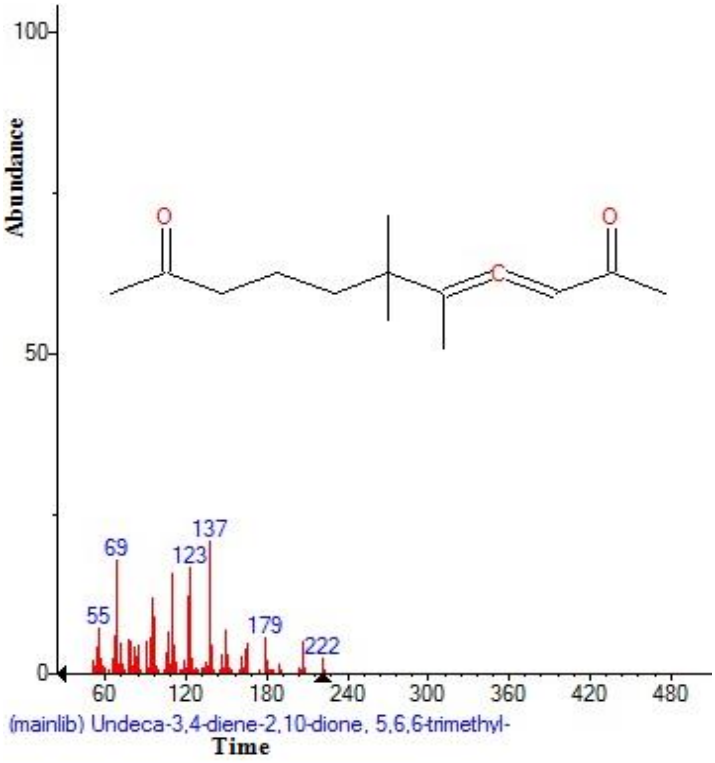


Figure 59. Structure of Undeca -3,4-diene-2,10-dione,5,6,6-trimethyl present in the methanolic seeds extract of *F. vulgare* using GC-MS analysis.

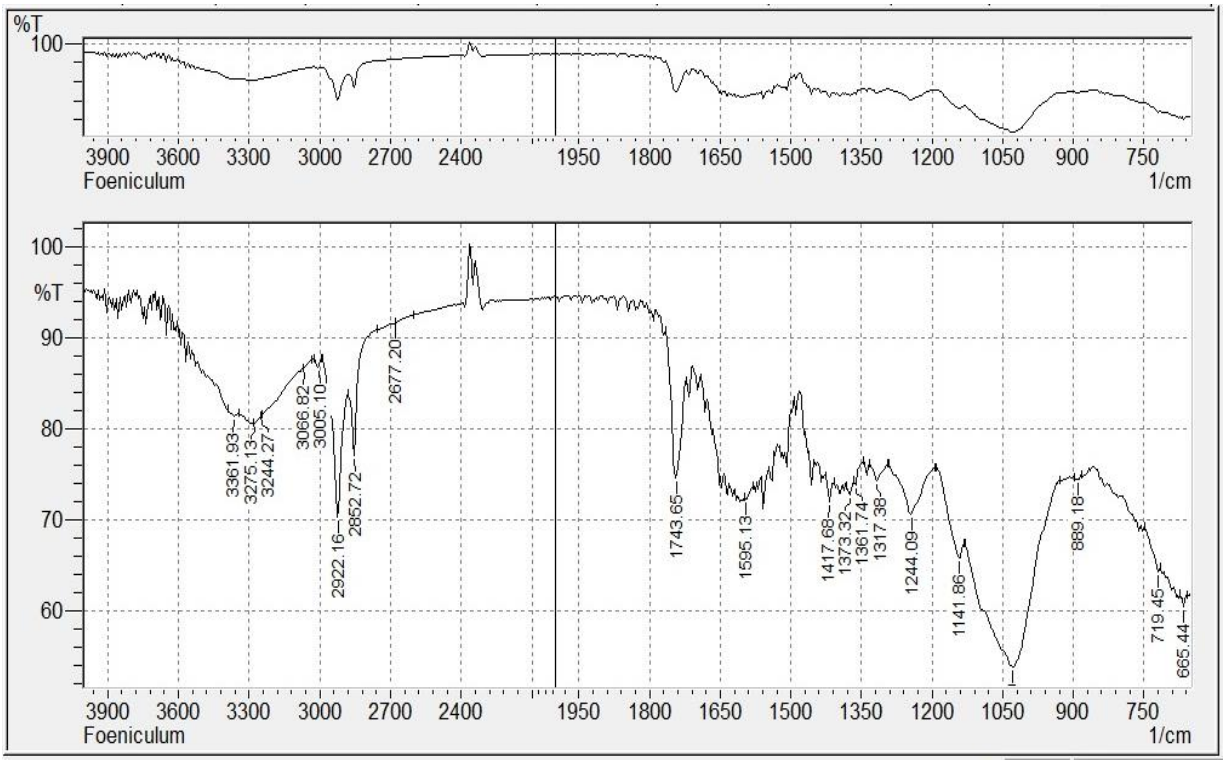


Figure 60. FT-IR profile of *F. vulgare.*

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